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Photographic Plates

Readers of *The Naturalist* will have noticed that the number of photographic illustrations has increased in recent years. Good clear photographs, suitably captioned, to accompany articles or as independent features, such as the bird portraits by Arthur Gilpin in recent issues, are always welcome.

To encourage this development, a long-standing member of the YNU, who wishes to remain anonymous, has most generously offered to make a donation, the income from which would finance the publication of a plate or equivalent illustration in future issues whenever possible. The editor, on behalf of the YNU, wishes to record his deep appreciation of this imaginative gesture.

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FRESHWATER ALGAE IN YORKSHIRE

Presidential Address to the Yorkshire Naturalists' Union, Wilton Castle, 5 December 1992

GORDON F. LEEDALE

Freshwater algal records for Yorkshire go back a long way but there have been relatively few research investigations even though the county is rich in interesting lakes, meres, ponds, marshes, rivers and streams. Accordingly, when I first came to Yorkshire in 1959 I decided to make use of these habitats in my research which is mainly concerned with cell structure of freshwater microalgae, especially plankton and, above all, *Euglena*. Taking stock over thirty years later shows that these studies have utilised numerous sites but I shall confine my remarks today to just two of the most interesting.

Those of my fellow naturalists who study beautiful birds, or wild flowers, or butterflies and moths, or other marvels of natural history, may wonder why someone actually chooses green slime! Well, as I hope to show you, providing one has access to good microscopes, the algae are just as beautiful and fascinating as any other organisms.

Sawley Dene

My first site is Sawley Dene, a shallow eutrophic lake in North Yorkshire near Fountains Abbey. This may sound familiar to some of you since I reported on the periodicity of phytoplankton in this lake with two students, Helena Cmiech and Tony Rees, in *The Naturalist* in 1984.

Two main peaks of biomass occur annually, diatoms in winter/spring and bluegreens in late summer. One of my hobbies is trying to capture the beauty of these microorganisms by colour photography in the light microscope and black-and-white photography in the scanning electron microscope. What I intend to do today is pictorialise our 1984 account by showing you some of the attractive algae that occurred. This will work well for my spoken address but will not make much impact in the written version without the colour photographs!

The lake is actually too shallow to stratify (become layered) and is really a large pond. However, because there is virtually no inflow in the summer, the lake acts like the epilimnion (top layer) of a stratified lake such as Esthwaite in the Lake District and nutrient inflow in autumn acts like the overturn of a larger lake.

Asterionella and other diatoms peak in February, March and April, bluegreens in September and October, and other algae mainly in summer, often just before the bluegreens. These other algae include dinoflagellates, chrysophytes like *Mallomonas*, the euglenoid *Trachelomonas*, and green algae such as *Eudorina* and desmids. The autumnal bluegreens are dominated by blooms of *Anabaena* but large populations of *Aphanizomenon*, *Gomphosphaeria* and other interesting genera also occur.

Helena Cmiech and I have written a long series of research papers on the cytological changes in the bluegreens in natural conditions over several seasons in Sawley Dene. This is the first study of its kind and Sawley Dene is now known worldwide. Electron microscopy shows many changes in cell inclusions as filaments appear, grow, develop and age. One new observation, among many, is that akinetes germinate immediately and serve to take the bluegreens out of the plankton and into the mud, rather than being resting spores.

Tholthorpe Village Pond

Our second destination is Tholthorpe in the Vale of York where, in the summer of 1980, the village pond turned bright red and the Parish Council anxiously sought advice from biologists at Leeds University. "Is it dangerous? Is it an act of God in retribution for village

sins? Can it be got rid of?" The call for help was passed to me and after viewing the phenomenon I said, "Don't panic! Very interesting! May we study it over the next few years, please?"

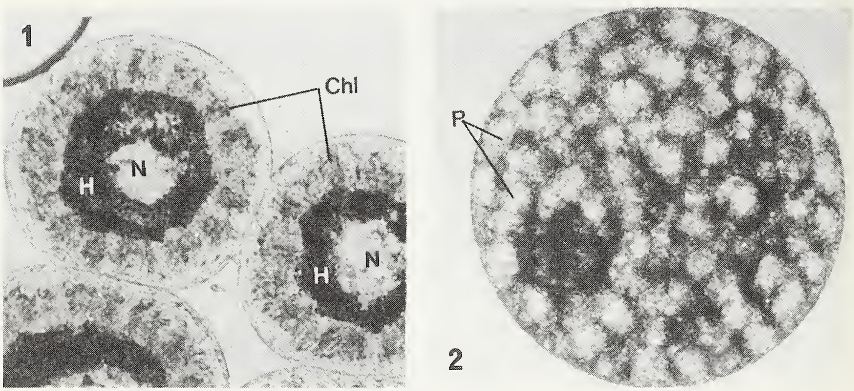
I was immediately interested because I realised that the redness was caused by an algal bloom. What is more, the appearance of a surface skin on the water (looking as though someone had thrown a pot of paint over the pond), bright red in full sunlight but turning green in overcast conditions, recalled records from around the world of a red species of *Euglena*, my favourite research genus.

A PhD student from South Africa, Heather Christie, was just starting to work with me when the Red Pond of Tholthorpe manifested itself and it soon became her research topic. After some preliminary studies, our main biological questions were (1) What causes the red bloom? (2) Why has it suddenly appeared? (3) Why and how does it change from red to green to red again? and (4) Why does it float?

Fortunately, the bloom appeared for three summers from 1980 to 1982, enabling us to collect and study material by light and electron microscopy over a prolonged experimental period. Yorkshire TV featured it as "The Traffic-Light Pond" and even the tabloid press took up the story ("Red Cells in the Sunlight" – Ouch!). In my spoken address I can again show you the beauty of the colour-changing cells of the red *Euglena*. In the written version we will have to manage with black-and-white, including just a few of the many fascinating electron micrographs from a very detailed study.

(1) The red colour was caused by a bloom of *Euglena sanguinea*, a rare microorganism. In the floating mass the rounded cells lie in a raft of mucilage; transferred to clean water they elongate and start to swim. The first record of "Bloody Euglena" perhaps occurs in *Exodus* 7, 14-20:

> The Lord said to Moses, "Tell Aaron to take his stick and hold it out over the rivers and pools in Egypt. The water will become blood, and all over the land there will be blood even in the wooden tubs and stone jars". And Aaron raised his stick and struck the surface of the river, and all the water in it was turned to blood. The fish in the river died, and it smelt so bad that the Egyptians could not drink from it.



FIGURES 1 & 2
Living cells of *Euglena sanuinea*. Light microscopy. X 800.
Fig.1. Green cell in green bloom; the red droplets (H) surround the central nucleus (N), the chloroplasts (Chl) are exposed.
Fig.2. Red cell in red bloom; the red droplets are dispersed in the cell periphery, the chloroplasts are hidden. P = paramylon (storage material).

In 1838, Ehrenberg considered this red plague was caused by *E. sanguinea* in shallow pools following annual flooding of the river. Discovery of *E. sanguinea* in the Tholthorpe pond enabled us to carry out the first modern study of its structure. Electron microscopy revealed radiating chloroplast ribbons and many unique ultrastructural features.

(2) The organism appeared suddenly in Tholthorpe following pig-slurry manuring of the surrounding farmland and a consequent huge increase of nitrate levels in the pond. It has to be presumed that *E. sanguinea* was already present in the pond in small numbers. It has never been recorded from anywhere else in Britain though it is known from Europe, China, Argentina and Australia. Once the manuring stopped the blooms declined and by 1983 had ceased altogether. However, scattered living cells of the red *Euglena* can still be found in the pond's mud to the present day.

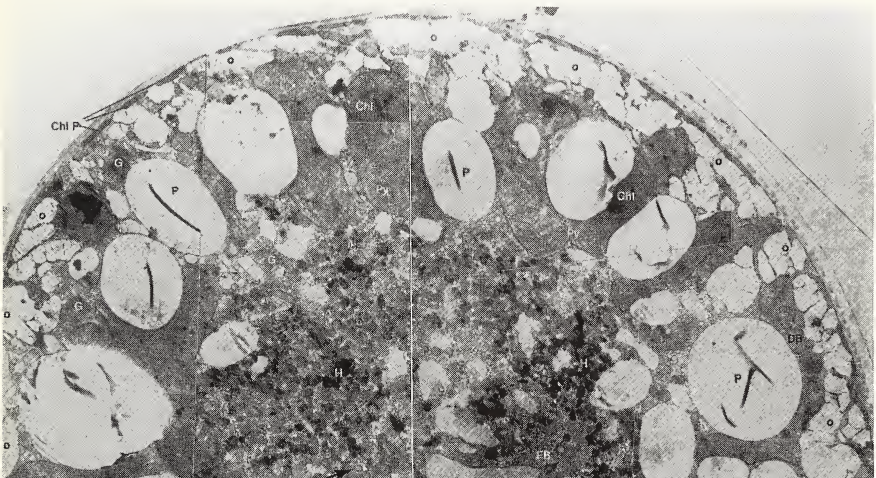


FIGURE 3
Multiple electron micrographs montage showing a transverse section through a green cell of *Euglena sanguinea*. As in Fig. 1, the red droplets (H) are in the centre, the chloroplasts (Chl) are exposed between the paramylon granules (P). X 2000.

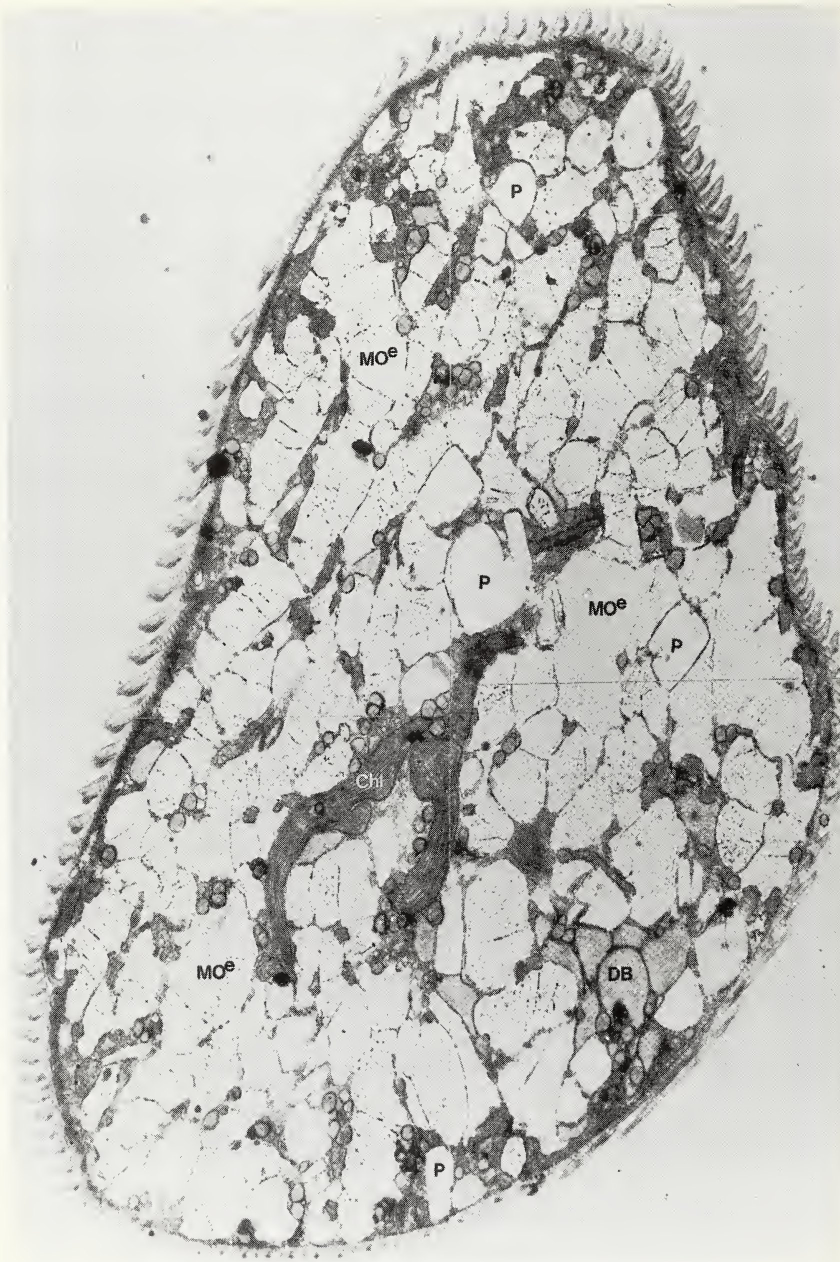


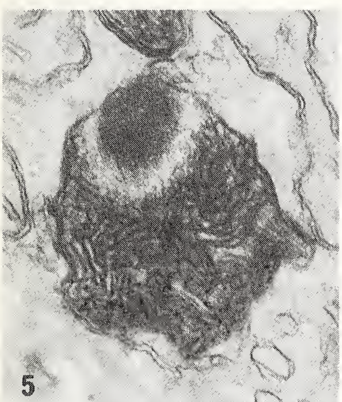
FIGURE 4
Electron micrographs montage showing a section through a floating cell of *Euglena sanuinea* which is full of expanded mucilage bodies (MO^e). X 5000.

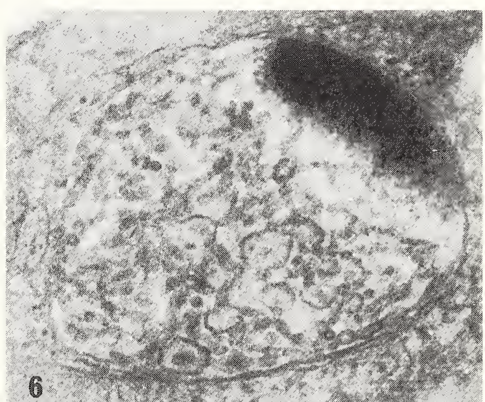
(3) On cloudy days the floating bloom was green; in bright sunlight the bloom was red. Change from green to red when the sun came out took about 20 minutes. When the pond was green individual cells were green. Vast numbers of red pigment droplets congregated in the centre of each cell while the green chloroplast ribbons were displayed around the cell periphery for photosynthesis (Fig. 1). When the pond was red individual cells were red. In bright light the red pigment droplets migrated to the cell surface and spread out as a screen to protect the chloroplasts from damage (Fig.2).

Electron microscopy of green cells showed huge numbers of carotenoid-containing lipid droplets in the cell centre (Fig. 3); the cell periphery was occupied by chloroplasts, storage granules of paramylon, and other organelles and inclusions. In red cells and cells turning red, the pigment droplets were dispersed along tracks of microtubules and microfibrils to become concentrated at the cell surface.

(4) Mature floating cells also became filled with a bubbly mass of expanded mucilage bodies (Fig. 4). This is why the cells float. The internal changes of the mucigenic bodies from very dense (Fig. 5) to fully expanded (Figs. 6-8) are unique to *E. sanguinea*. Most planktonic organisms swim to the water surface in dull light and into the shade or deeper water in full sunlight. Because *E. sanguinea* cells float they have evolved a unique method of light protection. A mobile screen of hundreds of sunshade droplets that are centralised in the cell when conditions are optimum for photosynthesis, spread out in sunlight to protect the chloroplasts from sunburn.

Sawley Dene and Tholthorpe Pond are just two of the freshwater sites in Yorkshire that have provided ideal situations for algal research. Studies will continue and I hope that future generations of microscopists will be as enthralled as I have been by the intricate structure, fascinating biology and supreme beauty of the microalgae.



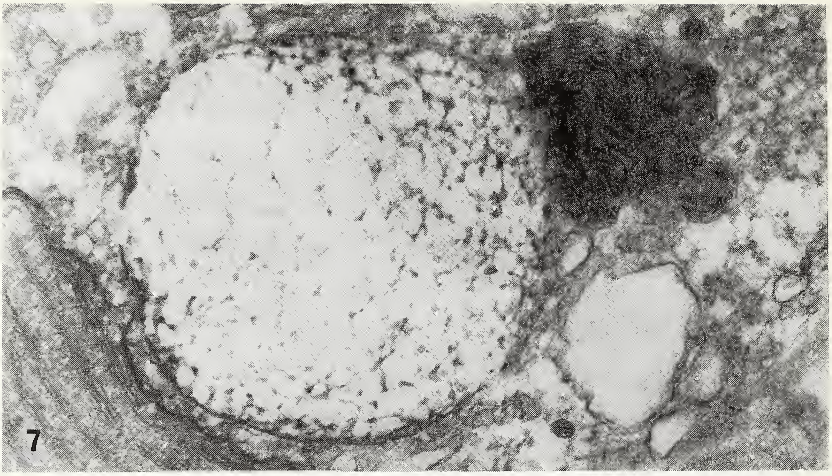


FIGURES 5 & 6

EM sections of mucilage bodies of *Euglena sanuinea*. X 70,000.

Fig. 5. Condensed body (initial state), showing a dense granule and a membranous region.

Fig. 6. Body starting to expand; the membranous region is larger and more diffuse.



FIGURES 7 & 8
EM sections of mucilage bodies of *Euglena sanguinea.*
Fig. 7. Part of the membranous region has expanded into a mucilaginous mass; the body is much larger. X 35,000.
Fig. 8. All the membraneous region is now bubbly mucilage but the dense granule can still be recognised. X 50,000.

ANNUAL AND LONG-TERM OBSERVATIONS ON THE CNIDARIA INHABITING AN INTERTIDAL MUSSEL BED IN MORECAMBE BAY, LANCASHIRE

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Introduction

Whilst there have been numerous studies of the flora and fauna of rocky, sandy and muddy shores, usually over a relatively short time span, little has been published on the biota of mussel beds, particularly that based on observations made over an extended period. This paper describes the distribution in space and time of Cnidaria species on the Heysham mussel bed (grid. ref. SD4163). The period of study was 1956-1990, excluding 1962, September 1973-January 1976, and January 1979-1982.

Study Area and Methods

The study area and methods employed here have been fully described elsewhere (Jones & Miller 1966; Jones & Clare 1977). The mussel bed is on an area of small stones, with scattered large stones and boulders, and is exposed to strong tidal currents. The common mussel, *Mytilus edulis* L., is widespread and abundant below MLWN, but more localised above. Many pools are present on the mussel bed, which are submerged every day.

Each area of the shore was examined for about 2 hours, by walking a defined search path and examining the same stones, boulders and pools each month. If conditions proved unfavourable the nearest pools or boulders were examined. The tidal levels and vertical ranges of these areas have been described elsewhere (Jones 1987). Search paths 1 and 2 were both recorded as high areas (the data from which were pooled), search path 3 as middle area, search path 4 as low area, and search path 5 as LWS. The latter area presented a special problem since during winter months complete daylight searches could not be made; at such periods a torch was used. Partial examination did at times affect the recorded abundance of certain species; on these occasions the abundance of organisms before and after the partial examination was used to estimate the abundance for these months. The abundance of species during the last 4 months of 1973 was estimated where necessary from the results obtained in other years. The estimated values ranged from 0.1% of total observations for *Gonothyraea loveni* (Allman) to 4.3% for *Metridium senile* (L.).

An arbitrary system of recording population sizes was followed using the terms "rare" – 1-3 individuals or small colonies, "frequent" - more than 3, but inconspicuous, "common" – conspicuous in some habitats, and "abundant" – conspicuous and using most habitats. These categories were scored 1-5 respectively; 0=absent. While essentially subjective, this method enables broad comparisons to be made between the abundance of species over months and years. The temperature of the sea edge at low water was recorded on every visit.

Throughout this paper the taxonomy and nomenclature of Haywood and Ryland (1990) has been followed.

Results and Discussion

Hydroida

The following taxa were often recorded: *Tubularia larynx* (Ellis and Solander), *Sarsia tubulosa* (M.Sars.), *Clava multicornis* (Forskal), *Hydractinia echinata* (Fleming), *Bougainvillia ramosa* (van Beneden), *Gonothyraea loveni* (Allman), *Laomedea flexuosa* (Alder), *Hartaubella gelatinosa* (Pallas) and *Obelia* spp.. The vertical distribution of the hydroids, annual variation in abundance and reproductive activity, and long-term changes

TABLE 1
Hydroid species infrequently or rarely recorded on Heysham mussel bed.

Species	Records	Reproduction
Corymorpha nutans M.Sars	First recorded 1970, then during 10 of the remaining years	May and June
Garveia nutans Wright	1956-61, 1968-90. Conspicuous Nov-May	January-May
Dicoryne conferta (Alder)	Sept. 1966, Aug. 1969, Feb. 1970, Aug. 1976.	Present on each occasion
Clytia johnstoni (Alder)	First recorded Nov. 1966, then 7 of the remaining years	Always present
Opercularella lacerata (Johnston)	June 1977, Sept. & Nov. 1978, Feb. & June 1979	June
Halecium halecinum (L.)	One recording June 1977	Present
Dynamena pumila (L.)	One recording August 1958	Present
Amphisbelia operculata (L.)	One recording Feb. 1973	Present
Rhizogeton nudum Broch	Every year since 1987	April-May

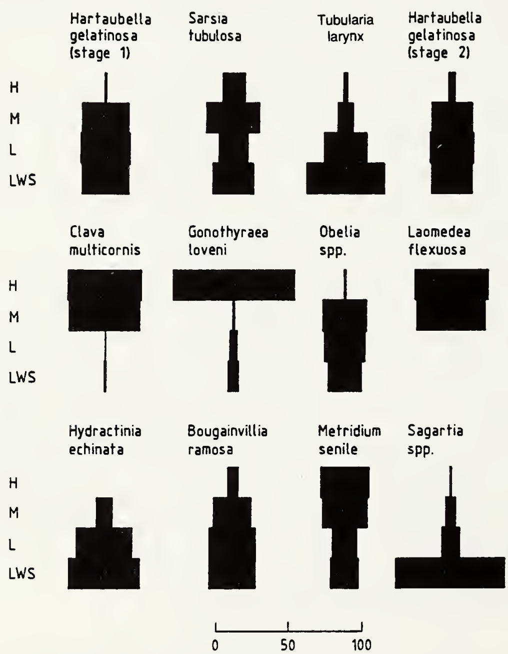

FIGURE 1
Vertical distribution of hydroid and anthozoan species on Heysham mussel bed. Relative abundance shown as percentage of all records at each shore level. H = high area; M = middle area; L = low area; LWS = low water springs.

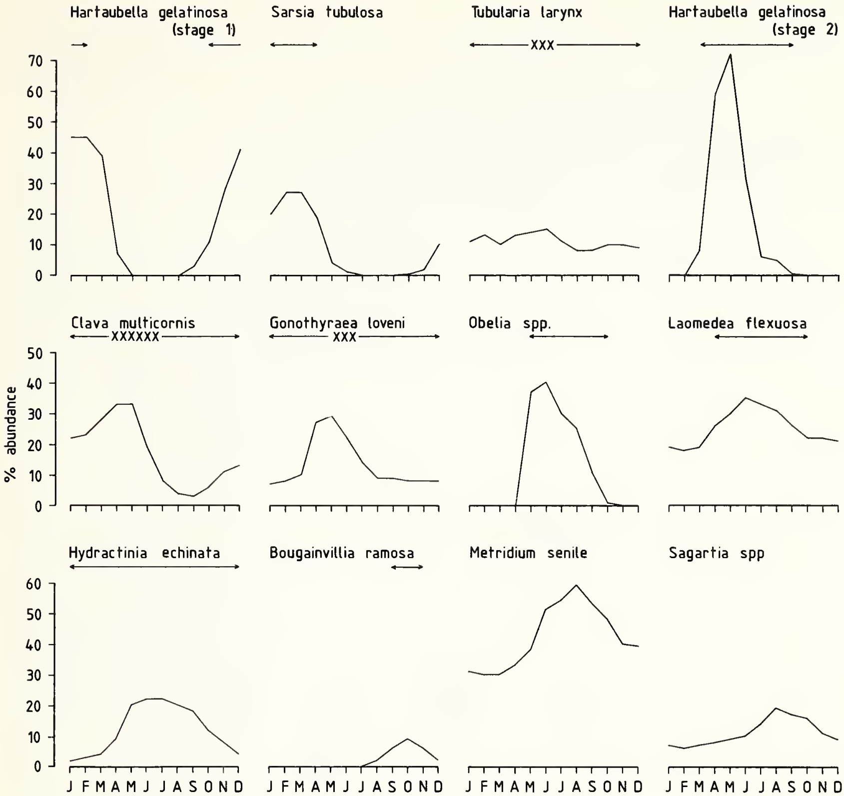

FIGURE 2

Seasonal succession of hydroid and anthozoan species on Heysham mussel bed. Mean abundance score (absent = 0, rare = 1, frequent = 2, common = 3, abundant = 4) for all shore levels combined expressed as % maximum possible score.
←——→ Gonophores or gonothecae present, XXX mature gonophores or gonothecae present.

in abundance are summarised in Figures 1-3. Records of the occurrence and timing of reproduction of other hydroid species are given in Table 1.

There was a clear pattern of vertical zonation (Fig. 1): *G. loveni*, *L. flexuosa* and *C. multicornis* being particularly abundant at the highest areas searched, *S. tubulosa*, *B. ramosa*, *Obelia* spp. and *H. gelatinosa* stages 1 and 2 mainly using the middle, low and LWS areas, with *H. echinata* and *T. larynx* at the lowermost area. Generally the less common species (Table 1) were found at the lowermost areas of the shore, the exception being *Clytia johnstoni* (Alder) which occurred up to the middle search path, *Rhizogeton nudum* Broch sharing the habitat of *C. multicornis* at middle and high areas, and *Opercularella lacerata* (Johnston) found only in the high area.

There was a marked seasonal succession of abundance (Fig. 2). *H. gelatinosa* stage 1 and *S. tubulosa* were the earliest hydroids to peak, in late winter, the last being *B. ramosa* in autumn. *Garveia nutans* (Wright) (Table 1) attained maximum abundance in the late winter and spring, *Corymorpha nutans* M. Sars. and *Sertularia argentea* L. in the early summer.

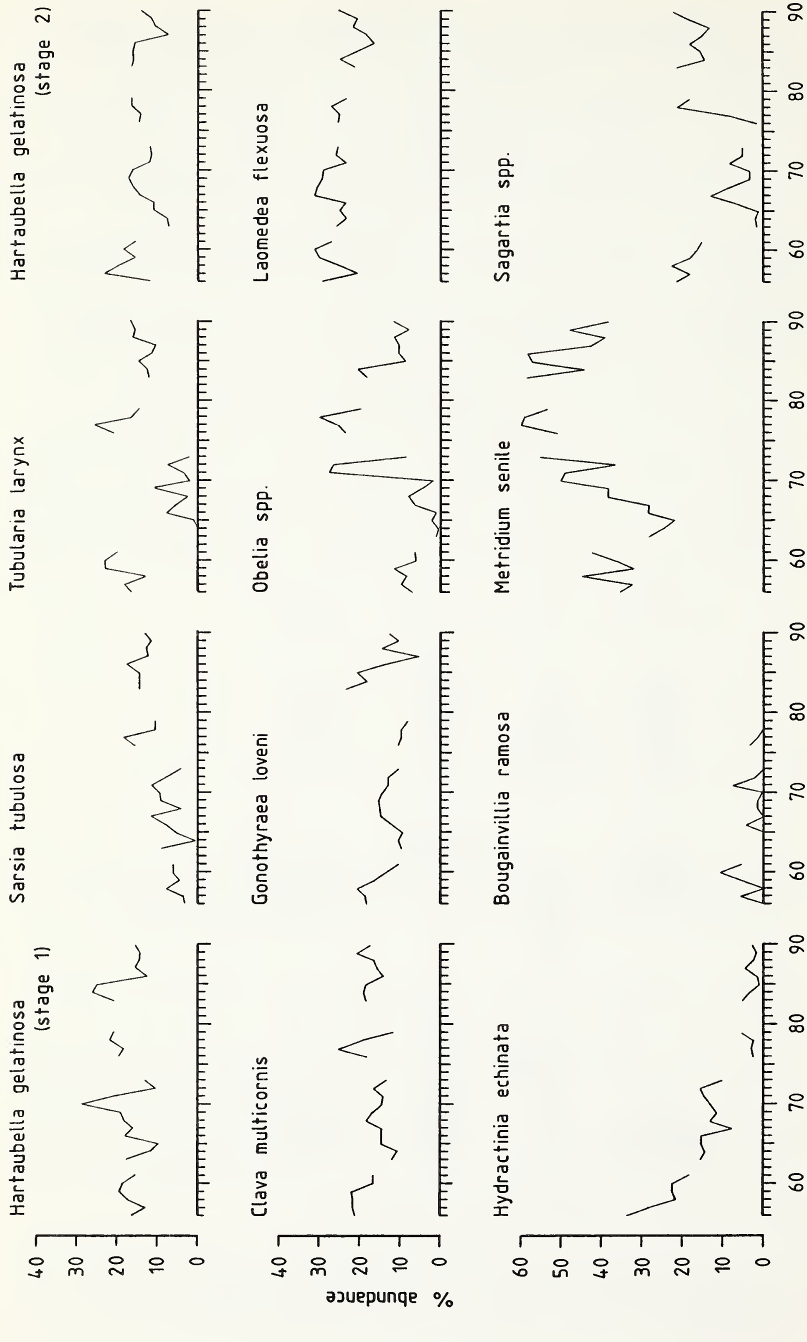

FIGURE 3

Long-term patterns of abundance of hydroid and anthozoan species on Heysham mussel bed. % abundance as in Fig 2.

Clava multicornis occurred on boulders, stones and shells. Colonies were always present on some boulders. While occasionally hydranths were visible all year round, during the autumn months they generally only existed in the form of a resting stolon. Colonies settling on stones and shells did not become permanently established. Gonophores were found in clusters behind the lower tentacles, becoming mature in April, May and June.

Gonothyraea loveni was found on boulders, stones and shells. Colonies on the high area boulders were present throughout the year, while colonies on stones and shells on other areas only occurred between April and July. These latter colonies were generally abundant but did not occur every year. The gonothecae produced hanging medusae that were never released.

Laomedea flexuosa formed permanent colonies on certain high and middle area boulders, often extending onto mussels that were attached to the boulders.

Tubularia larynx continuously settled then disappeared from boulders, stones and shells, never producing permanent colonies. It does not have a planktonic stage, the actinula larva sinking to the substrate, where it moves around on its tentacles before eventually attaching itself. Daughter colonies therefore would not be expected to settle very far from the parent colony; this may explain why when *T. larynx* was lost after the cold winter of 1962-63 the level of abundance recorded before 1963 was not restored until 1976 (Fig. 3).

Sarsia tubulosa was found in all months with the exception of July, August and September. Settlement was on boulders, stones and shells. Free-swimming medusae were produced during the first 4 months of the year (Fig. 2). Colonies appeared on the same parts of some boulders most years, suggesting that a resting stolon may produce hydranths the following season.

Spherical colonies of *S. tubulosa* appeared in 1969, becoming abundant during 1970. They were common in 1978 and 1985, rare in 1972, 1977, 1979, 1984 and 1987. A possible explanation for the formation of the rolling colonies is given in Clare et al. (1971). The planula larva may have been affected by a chemical pollutant followed by recovery and multipolar growth under natural conditions in the plankton.

Hartaubella gelatinosa stages 1 and 2 settled on boulders, stones and shells, but not on the same ones season after season. It is therefore assumed that the littoral population is maintained by settlement of larvae from the plankton. Gonothecae were rarely found on stage 1, yet reproductive structures were always present on stage 2. Both stages appeared without great variations in abundance every year of the study period (Fig. 3).

Only *Obelia dichotoma* (L.) was positively identified amongst the abundant *Obelia* colonies that were present during the summer months, but other species may have been present. Reproduction was by medusae with larval settlement from the plankton on boulders, stones and shells. Colonies were not found on the same ones each year. No obvious reason for the large variation in abundance (Fig. 2) could be found; however, their settlement period of late spring and summer means that the demand for habitats is at its greatest during settlement.

Active colonies of *Bougainvillia ramosa* were found on stones and shells during the last 5 months of the year, occasionally remaining in skeleton form until February. Reproduction was by medusae during September, October and November (Fig. 2).

Hydractinia echinata was found mainly on gastropod shells occupied by the hermit crab *Pagurus bernhardus* (L.), but colonies were occasionally found on stones and wood, and on one occasion on the carapace of the shore crab *Carcinus maenas* (L.). No reason for the steady decline in abundance of *H. echinata* (Fig. 3) could be found; the numbers of *P. bernhardus* remained fairly constant throughout the survey. However once the decline had commenced, the relative immobility of its larvae may have contributed to further reduction in abundance, given the specialised nature of its microhabitat.

No data are presented for *Sertularia argentea* L., even though it was abundant during some years, because many colonies remained in skeleton form for long periods and could not be unequivocally separated in the field from living forms. It was recorded as frequent every year from 1956-61, and rare from 1963-78, with the exceptions of 1966 and 1967

when none were found. It was common or abundant from 1978 to the end of the survey. Settlement from the plankton took place in July, August and September.

Of the hydroids that were infrequently or rarely recorded (Table 1), *G. nutans* was the most consistent in occurrence although only found on one group of boulders at LWS. It was active from November to the following May and gonophores were produced from January to May (Table 1). During the remaining months it was present in a resting stage. The colonies were lost after the cold winter of 1962-63 until 1968 when they returned. Settlement was on the same boulders.

Rhizogeton nudum was recorded for the first time in the British Isles during this survey (Jones 1992). It settled on boulders and mussel shells attached to these boulders, with already established colonies of *C. multicornis*, in April and May of 1987 and each subsequent year. In 1989 it also appeared in March. Gonophores were observed during April and May. The ovoid female gonophores have ova which on release remain adhering to the gonophore by mucus for some time. The immature male gonophore has a spadix; as it matures it becomes white with sperm within. As *R. nudum* appeared at the same sites each year, it seems likely that a resting stolon remains until conditions again favour development.

Corymorpha nutans was only found from 1970, appearing in 10 of the remaining years. Individuals were found between mussels, attached by a network of adhesive "rootlets" to the muddy substrate. It was always recorded as rare and no specimens remained for more than one month.

Clytia johnstoni was first found in 1966 and appeared in 7 of the remaining years. It was found on stones, shells, seaweeds and the hydroid of *S. argentea*. It is not a conspicuous hydroid, and colonies found in one month had disappeared by the next. *C. johnstoni* was most likely to be found from July to November. Gonothecae were always present.

Opercularella lacerata was only found on one high area boulder and on mussels attached to the boulder. Only 5 recordings were made between February and November. Reproductive structures were present each time.

Dicoryne conferta was found on the shells of *Buccinum undatum* L. It is perhaps surprising that only 4 sightings occurred during such long term observations because substantial numbers of *B. undatum* were found, particularly during the winter months when egg-laying was taking place.

Halecium halecinum, *Dynamena pumila* and *Amphisbelia operculata* each failed to form permanent colonies, only one recording of each species being made throughout the survey. The study period covers years when extreme temperatures were recorded, the lowest being during the cold winter of 1962-63, when pools were covered with ice, and ice floes occurred in the edge of the tide. In the winter of 1978-79 pools were again covered with ice but the cold weather was not as severe or as prolonged. The warmest winter recorded was 1989-90, and the warmest summers 1976, 1983, 1984 and 1989. During the cold winter of 1962-63 two of the most abundant hydroids, *H. gelatinosa* stage 1 and *S. tubulosa*, maintained their abundance (Fig. 3), and apart from *T. larynx* the species present during the winter months generally showed little variation in abundance. Crisp (1964) found that the cold winter of 1962-63 had little effect on hydroid species. It was noted, however, that taxa which peak during the spring and summer, *H. gelatinosa* stage 2 and *Obelia* spp., were less abundant during 1963. This is surprising because when they settled temperatures were close to normal. As these species do not develop each year from a resting stolon, perhaps their parent colonies in the sublittoral zone, or the planktonic stages from these parent colonies, were in some way affected. The cold winter of 1978-79 produced only a small decline in the abundance of hydroid species from the previous year. The abundance of hydroids was well maintained during the warm winter of 1989-90. While generally high numbers occurred during the warm summer of 1976, it is unfortunate that no records are available for the previous 3 years for comparison. However, abundances were also high during the warm summers of 1983 and 1989.

Methods of reproduction have a bearing on the presence and yearly patterns of

abundance of hydroid species. *Clava multicornis*, *G. loveni* and *L. flexuosa* were present on some boulders throughout the study period. All have planulae that settle quickly in the vicinity of parent colonies.

Several species of sea slug (Gastropoda: Opisthobranchia) were found on hydroids: *Tergipes tergipes* (Forskal) and *Eubranchus exiguus* (Alder & Hancock) on *Obelia* spp., *G. loveni* and *H. gelatinosa*, *Cuthona nana* (Alder & Hancock) on *H. echinata*, *Cuthona concinna* (Alder & Hancock) on *H. gelatinosa* and *T. larynx* and *Doto coronata* (Gmelin) on *S. tubulosa*, *S. argentea* and *C. multicornis*. Sea slugs were seen to feed on hydroids, but there was no evidence that such predation significantly reduced abundance. *S. argentea* was occasionally covered with tiny mussel spat.

Actiniaria

The following taxa were recorded: *Metridium senile* L., *Sagartia* species: *S. elegans* var. *miniata* Dalyell, var. *nivea* (Gosse) and var. *rosea* (Gosse), *S. troglodytes* var. *decorata* (Price) and var. *ornata* (Holdsworth). Other species recorded were *Actinia equina* L., *Urticina felin*a L. and *Diadumene cincta* (Stephenson).

Metridium senile var. *dianthus* was readily identified, but only rarely recorded. The abundances shown in Fig. 3 are of small forms of *M. senile*. They used all habitats, being found on boulders, stones and shells and partly buried in the substrate with or without attachment to a solid surface. During some summers abundant populations appeared in the latter habitat at LWS. These were generally lost during the winter months when many unattached specimens were found rolling in the tide. Colonies on boulders formed more stable populations. One such colony existed beneath a boulder in the high area throughout the study period, individuals never growing to more than 2 cm across the disc. The yearly variations in abundance (Fig. 3) were mainly due to the arrival and eventual success of the individuals using the substrate at LWS. Laceration of the base and budding were observed as methods of reproduction.

Adult *Sagartia* species, with the exception of *S. troglodytes* var. *ornata,* were found with their columns buried in the substrate. Juveniles were located beneath stones and shells. Assessing their abundance was extremely difficult because specimens only occasionally remained open when the tide receded, generally contracting and leaving a small hole in the substrate to denote their presence. While their numbers were greatly reduced during the cold winter of 1962-63, those found were healthy, and the less prolonged cold winter of 1978-79, had little effect on their abundance.

Although good numbers were again noted in 1967 it was not until 1979 that the level of abundance recorded before 1963 was restored (Fig. 3). *Sagartia* species were recorded in Morecambe Bay by Gosse (1860), but no details of abundance or distribution were given. *Sagartia troglodytes* var. *ornata* was only found in the high area, and was not common. Specimens were partly buried in the substrate or attached to stones or shells. They were recorded each month from March 1957 to December 1960, but subsequently only 3 recordings were made, one in 1961 and two in 1971.

Recording of *D. cincta* was restricted to one colony. Although they were sometimes found on a group of boulders at LWS it was not possible in the field to separate them from small *M. senile* that shared this habitat. The recorded colony was a densely crowded cluster beneath an overhang on a high area boulder. This colony persisted from January 1956 to August 1964 when unfortunately the substrate accreted to cover the overhang.

U. felina was found partly buried in the substrate at LWS. It was present every year throughout the study, being most frequent from 1956 to 1960, and 1983 to 1990. It did not form obvious aggregations. No juveniles appeared in the population.

A. equina was most often recorded in the high area. Its appearance was sporadic; individuals would appear one month only to disappear the next. However, 3 individuals remained on a stone in one pool for 10 months.

The sea slug *Aeolidia papillosa* (L.) was seen attacking *M. senile*, *Sagartia* species, and *U. felina*. The defence of *M. senile* was to extend the column and then detach itself.

Sagartia species withdrew into the substrate, juvenile specimens beneath stones or shells, expanding the column and ejecting acontia. *U. felina* had no apparent defence.

The shore levels and microhabitats occupied by the anthozoans on the mussel bed are consistent with those recorded by Stephenson (1928, 1935) and Manuel (1981).

Scyphozoa

Colonies of the scyphistoma of *Aurelia aurita* (L.) were found on boulders and stones at LWS in January 1956 and July 1956, 57, 58 and 60. During 1958 they remained until November.

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A REVIEW OF THE GRAYLING (*Thymallus thymallus* L.) IN YORKSHIRE AND SOME RECORDS OF TRANSFERS OF FISH AND OVA

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Introduction

The European grayling(*Thymallus thymallus*) is a salmonid fish which is found in cold water between latitudes of 40° and 70° north. The very similar Arctic grayling *T. arcticus* is widespread in suitable habitats in Asia and in North America. The grayling is instantly distinguishable from all other salmonids by its very large erectable dorsal fin. The name grayling is at least five centuries old and is believed to be a corruption of "gray lines", a name derived from the distinct pattern of dark longitudinal lines on its flanks. The derivation of its other colloquial name 'Umber', now obsolete, is more obscure and various theories have been put forward (Magee 1992).

The grayling is not an introduced species in England but whether or not it re-colonised England from sub-arctic regions of Northern Europe, or from the Danube basin via the east-flowing rivers of England while England was still joined to the European mainland remains a matter of speculation (Platts 1939).

Historically, the grayling was thought to be confined to some rivers draining into the North Sea and the English Channel but its distribution in the British Isles became better understood and well documented during the 19th century. The main reasons for this were the rapid growth of the railways from 1840 onwards, making regions formerly remote readily accessible to sportsmen with the time and the means to travel, and the profusion of angling literature after Waterloo, especially books on flyfishing and the development of pisciculture, particularly trout breeding.

The grayling is considered to be an endangered species in Britain: it has become extinct in some streams where it was formerly abundant and is declining in others. The causes of the decline are various but pollution, water extraction, exploitation, habitat changes and disease have all played some part (Magee 1992).

Habitats

The grayling does not occur in Ireland and does not naturally inhabit lakes but there are at least two lakes, Gouthwaite Reservoir in Yorkshire and Llyn Tegid in Wales, where the fish are known to migrate from the river to the lake and vice versa at different times of the year.

It has two distinct types of habitat in the British Isles and certainly has a preference for alkaline waters. The first type of habitat is the mid-reaches of stony-bottomed spate rivers which also have pools and glides with sand and gravel, such as the Wharfe and the Ure. The second type is the so-called chalk streams of the lowlands which are spring fed and have a less rapid descent from the sources, such as the Costa Beck (North Yorkshire) and the Test in Hampshire.

Distribution

Grayling remains have been found in archaeological deposits in the York area dating from the 1st to the 12th centuries (Jones 1988). This tends to confirm that the grayling is indigenous to the Yorkshire Ouse river system, and that the historical records for the Humber are correct, if one accepts that in that context 'Humber' refers to the system of rivers draining into the Humber rather than the specific river. Taylor (1800), writing of Yorkshire rivers, is precise: "This county is watered by an abundance of rivers; the principal of which are the *Humber*, though this is not properly a distinct river, as not having a spring-head of its own, but rather the mouth or receptacle of divers other rivers . . . especially the

Trent, the *Ouse*". Especially interesting is his mention of the Golden Umber. "The river Humber is said to produce the greatest quantity of that sort of fish which in this part of the country is called the Golden Umber, and in other counties the Grayling; and though some are of the opinion that they really are a different species of fish, yet I am convinced that they are not, but that different counties give them separate names." One 20th century writer has remarked on the variation in colouring of Yorkshire grayling: "some golden, some steely and others lilac . . ." (Rhygini 1968). All the main rivers draining into the Ouse, with the exception of the Calder, still have populations of grayling.

The earliest printed records of grayling in the British Isles are to be found in angling literature, the first being that in *A Treatise of Fysshinge wyth an Angle* (1496) printed by Wynkin de Word at Westminster. The second is that of Isaac Walton in *The Compleat Angler* (1653) where he mentions its presence in "the Derbyshire Dove, the Trent and some small rivers as that which runs by Salisbury". This is the first mention that I have been able to find of the grayling living in rivers draining into the Humber.

The first printed reference to the grayling in Yorkshire is that of John Aubrey in *The Natural History of Wiltshire* (1660): " . . . it hath in it a rare fish called the Umber . . . This kind of fish is in no other river in England except the river Humber in Yorkshire". The next record for Yorkshire rivers seems to be that of Dr Richard Brooks (1740): "They delight in rivers that run through mountainous places and one to be met with in the clearest and swiftest parts of those streams, particularly they are bred in the Hodder, Dove, Trent, Derwent, Humber, Wye and the Lug". [The Hodder and the Humber are Yorkshire rivers, although the tidal Humber is an unlikely habitat.] The book ran to fourteen editions, the last being in 1811; many authors of angling books quoted the same distribution almost verbatim.

According to *The Sportsman's Dictionary* (Anon. 1792), "The Grayling is found in plenty in many rivers in the North, particularly in the Humber and in the Wye which runs through Herefordshire and Monmouthshire into the Severn". Whittaker (1818) mentions in passing, "the beautiful river Hodder, famous for its Umber . . . rising near the Cross of Crete". Sir Humphry Davy (1828), the scientist and much travelled angler, wrote: "the grayling is a rare fish in England and has never been found in Scotland or Ireland, I know it no further west than the Avon in Hampshire . . . In Derbyshire, Staffordshire, the Dove, the Wye, the Trent, and the Blythe afford grayling; in Yorkshire, on the north coast, some of the the tributary streams of the Ribble; and in the south, the Ure, the Wharfe, the Humber, the Derwent, and the streams that form it, particularly the Rye".

John Turton (1836) of Sheffield began flyfishing for trout on the head waters of the Don around the turn of the century but wrote that there were no grayling there. Since he describes in detail the Derbyshire and Staffordshire rivers in which he had found grayling plentiful, it seems unlikely that they were present anywhere in the Don at that time. He does mention the pollution from 'manufactories' which even at that date was becoming widespread on the Don and the grayling is very susceptible to pollution in its many forms.

Ronalds (1836) quotes Sir Humphry Davy in full but acknowledges the author. Other references are:

Yarrell (1836): "In Yorkshire, in the Derwent, the Ure, the Wharfe and the Whiske near Northallerton".

Shipley and Fitzgibbon (1838): "In Staffordshire in the Hodder [the Hodder is actually a tributary of the Yorkshire Ribble] . . . in Lancashire in the Ribble, . . . in Yorkshire in the Derwent, the Ure, the Wharfe, and the Whiske near Northallerton". Pennell (1895) quotes the above almost verbatim, with the same errors.

Hofland (1839) refers to Harewood on the Wharfe: "Here the grayling are much more abundant than at Bolton. [Bolton Abbey, further upstream] I have seen shoals of them swimming near the the sparlings of the bridge . . . during my residence at Harrowgate this was a favourite resort of mine".

Denny (1840): "*Thymallus vulgaris* Rather local. Harwood, Bolton [Bolton Abbey] Wakefield".

Holland (1843): "The following fishes may be found in the Don and other streams in our

locality . . . salmon , trout and grayling . . . ".

Since the list of 21 fishes which he said were to be found in the Sheffield district includes the grayling, 'The Sheffield district' may well have included certain North Derbyshire rivers where the grayling was abundant. Turton (1836) stated that for 30 years he had travelled to Derbyshire for the fishing but he would hardly have done so if the local fishing was as good as Holland seems to indicate.

Jackson (1854): "There are no grayling above Aysgarth . . . about Clifton trout and grayling abound in considerable numbers and attain a good size . . . The Wharfe: Grayling are found but are not very numerous at Grassington . . . at Collingham the grayling are very numerous and predominate over the trout . . . The Rye: At Rievaulx the grayling fishing may be said to commence; the grayling are numerous and predominate over the trout".

Clarke and Roebuck (1881): "[Grayling] Freshwater resident, found in varying abundance in the middle waters of the Wharfe, Washburn, Nidd, Ure and Swale, also in the Cover, Whiske and Codbeck, the Rye and other tributaries of the upper Derwent and in the Scalby Beck near Scarborough. In the Tees it is very limited in numbers and it has been introduced into the Esk. Formerly abundant in the Ribble and Hodder, their extreme scarcity – if not extinction – being ascribed to the great increase in the salmon. It was also formerly abundant in the Aire about Bingley but in 1824 all were destroyed due to the bursting of a bog, subsequent attempts at re-introduction have as as yet proved ineffective".

Pennell (1895), recommending streams where the grayling might be successfully introduced, states (surprisingly for a stream noted for its large grayling), "Driffield Beck below Wandsford Mill seems exactly fitted to carry grayling side by side with trout".

Pritt (1886): "Kilnsey [Upper Wharfe] water holds no grayling".

Pritt (1888): ". . . the grayling was formerly plentiful in the middle reaches of the Ribble, about the Cistercian foundations of Sawley and Whalley. Of late years the fish had practically disappeared from this river but careful nurturing and preservation between Sawley and Gisburn have proved that the grayling will survive there as it did in ancient days . . . It is to be noticed that the grayling rivers of Yorkshire, some ten or eleven in all, join their broad waters in the Humber . . . The best grayling river of Yorkshire is the Costa". [It joins the Rye at Howe Bridge, north of Malton.]

Pritt (1888): "There are many fine streams on the Western side of the country in which it would prosper if it were properly introduced, . . . as indeed it would in the Hodder, the Lune . . .".

Walbran (1895): "The river Wharfe from Otley down to Harewood used to abound with grayling, but during recent years they have greatly decreased in numbers. Some 30 years ago (1865) one angler killed 75 grayling in a single day with fly only . . . The sole reason for the decline may be found at Ilkley and Otley where all the town's sewage has hitherto been turned direct into the river . . . There is also a large paper mill which has polluted the stream". [The Otley Angling Club was the first to successfully prosecute a local council for pollution in 1897 but merely achieved bankruptcy] "In Yorkshire, the Wharfe, the Yore, the Swale, the Derwent, the Costa and the Rye all abound with fine grayling".

Minute Book, Appletreewick, Barden and Burnsall Angling Club (1889), referring to the Wharfe: "There is a vast increase in the number of small grayling which is not looked upon as at all satisfactory and that grayling have increased inordinately at the expense of the trout".

ABBAC Minute Book (1906): "1671 grayling were netted out and distributed to the landlords and the tenants".

ABBAC Minute Book (1928): J. Bazeley complained of excessive numbers of grayling in the upper Wharfe, giving instances of 80 per day caught by individual anglers on rod and line.

Yorkshire Post (1929): "Stocks of grayling on the upper Wharfe now very low".

ABBAC Minute Book (1932): "It was decided that grayling should be netted out".

ABBAC Minute Book (1968): "Disease was reported in the Aire and the Ure". [This proved catastrophic for grayling stocks on both these rivers as well as the Wharfe, and it

was to be several years before there was a noticeable recovery, achieved mainly by restocking with fish from the East Riding and restrictions on culling].

Briggs (1991 Pers. comm.): "Very rare in the Wharfe between Otley and Harewood 1940-1965".

Grayling Introductions

Davy (1828) gives the first record of grayling being introduced into a river where they were not previously known: "The grayling were recently [1816] introduced into the Test". They flourished in this famous chalk stream and some 50 years later fish between two and three pounds were commonplace.

Turton (1836) gives the first note of grayling being introduced into ponds [in Darley Dale]: "We angled in three preserved dams, into one of which the owner had put many fine greyling [*sic*], – he being a young fly fisher himself. It was the only dam in which I ever saw them".

There are various contemporary accounts of the first grayling introductions into Scottish rivers. The following is from Hutchinson (1904): "In 1855, 36 yearling grayling were sent by mail train from the Derbyshire Wye to Abingdon on the Clyde".

"In 1857, The West of Scotland Angling Club obtained 10,000 grayling ova from the Derwent near Bakewell. The spawn was taken on 13th April 1857 and sent off the same night in common wine bottles half filled with water to Abingdon on the Clyde, about 50 miles above Glasgow, where the club had prepared a rill for its reception . . . It is a matter of history that this simple method of transporting grayling ova stocked the Clyde with the fish". Grayling fingerlings from the above experiment were transfered to the river Nith in 1858. From this period onwards, the transfer of grayling from one river to another and to higher reaches of the same river, where there were obstacles to upstream migration, became a regular occurrence. Not all transfers were successful; grayling transferred from the Costa Beck to the Yorkshire Esk in 1880 failed to survive. Transfers to the upper Aire failed also, although they are now established in the main river in the Skipton area.

Pritt (1888): ". . . half a dozen grayling introduced into the Aire at Keighley 12 years ago, have been sufficient to populate miles of good grayling water above the point at which they were turned in. Previous to the introduction of these fish, grayling had become extinct in the upper reaches of the Aire".

No evidence of transfer of grayling into Yorkshire from outside the county has been found to date; this is not surprising since grayling were to be had for the asking in a county where the fish was numerous and was considered vermin by many proprietors of trout streams. Large numbers of mature fish were transferred from East Yorkshire to the tributaries of the Ouse, mainly to replace stocks which had been wiped out by pollution. However, since the pollution was on-going, many of the introductions had to be regularly repeated. The dates of the transfers, numbers of fish, sizes, origin and the receiving river have survived in many instances and a list is given below, although it is not claimed to be complete by any means.

DATE	SOURCE	NUMBER	RECEIVING RIVER
1876	Wharfe	6	Aire (above Keighley)
1931	Costa Beck	31	Wharfe (Kirby) [Tagged fish]
November 1936	Golden Hill Driffield	1170	Wharfe; Swale
	Driffield	200	Nidd
1936	West Beck	200	Wharfe (Ulleskelf)
	West Beck	300	Wharfe (Pool Bridge)
	West Beck	250	Riffa Beck (Wharfe)

1937	West Beck	800	Wharfe (Pool), Riffa Beck
1937	West Beck	800	Wharfe (Kirby Wharfe)
Aug/Sept 1937	Ure at Wensley and Middleham	400	Nidd and Swale
Oct 1937	Wharfe (Burnsall) [4oz to 10oz]	500	Lower Wharfe
Oct /Nov 1937	Driffield Beck	2400	Leeds ASA waters on Nidd and Wharfe. (50% over one pound)
1939	West Beck	Part of 1500	Wharfe
1940	West Beck	Part of 1600	Wharfe
1942	West Beck	Part of 1200	Wharfe
1943	West Beck	Part of 1000	Wharfe (Pool)
1945	West Beck	800	Wharfe (Boston Spa and Wetherby)
1948	West Beck	400	Wharfe (Boston Spa)
1950	Aire (Broughton)	?	Wharfe
1956	Ure (Norton)	85	Wharfe
1958	Unknown	72	Wharfe (Harewood)
c.1960	Costa Beck	100	Aire (Keighley)
1961	Unknown	123	Wharfe (Harewood)
1962	Unknown	200	Wharfe (Harewood)
1963	Unknown	250	Wharfe (Harewood)
1965	Unknown	60	Wharfe (Harewood)

(In 1966 the Leeds Anglers' Association felt that at long last the grayling had been re-established in the Wharfe at Harewood and decided that members could take two brace per day from the river between Oct 1 and Jan 31 if they so wished. However in 1968 'fungus' disease wiped out the majority of grayling in the Wharfe from Burley to Boston Spa and re-stocking commenced in 1971.)

1971	Unknown	190	Wharfe (Harewood) 'Large fish'
1990	Reared from Nidd ova by NRA.	100	Wharfe (Arthington)

Factors which have affected the Grayling populations

Pollution

The 'grayling zones' of several Yorkshire rivers, particularly the Tees, Aire, Wharfe, Nidd and Swale, have suffered from pollution from lead mining for several centuries and the destruction of the grayling as a result is well documented. The situation worsened in Yorkshire from the beginning of the Industrial Revolution when noxious discharges came from woollen mills, dyeing, tanning, mining and paper mills. In addition, until late into the 20th century raw sewage was discharged directly into the rivers.

Drainage

Many small tributaries were turned into canals by continuous dredging; the Costa Beck,

once claimed to be Yorkshire's finest grayling river, was permanently affected by drainage operations.

Close Season

The brown trout has a close season lasting for six months, whereas the grayling close season lasts only from March to mid-June since it is classed as a coarse fish. This would not be so important except for the fact that grayling are killed for food and only the larger fish are taken. It has been argued that this results in greater numbers of small fish but this has not been substantiated in Yorkshire.

Culling

Owners and lessees of trout fisheries have until recent years encouraged the removal of grayling in the interests of trout. Formerly netting was widely employed but more recently electro-fishing has been used. Stock removed were given away as food, merely disposed of, or transferred to other rivers when there was a demand. Some fisheries had rules that all grayling caught by rod and line should be killed and encouragement was given to anglers to capture the maximum number possible during the close season for trout. Mottram (1928), writing of trout fisheries, says, "As regards grayling, if as usual, they are looked upon as vermin, then the rules should be that every grayling caught should be killed".

Impounding and Water Extraction

The tendency to augment water supplies by river transfer, in conjunction with extraction by pumping from downstream, is increasing and has changed the character of some grayling zones. As a result, the grayling stocks have become almost extinct on the upper Wharfe. Insufficient research has been done to determine the reasons but it is well known that mature and immature fish of all species as well as invertebrates are drawn into the pumps and destroyed. No successful method of preventing this has been found to date and the effect of extraction by pumping has been little studied.

Flora and Fauna of Grayling Zones

There has been a great reduction in the distribution of aquatic plants in some Yorkshire rivers during the post-war years, with a consequent reduction in the numbers of aquatic invertebrates. The density of grayling per hectare in the grayling zones appears to be directly related to the presence of aquatic plants (Magee 1992).

Disease

There is little evidence that disease has had a serious effect on grayling stocks in Yorkshire with the exception of the outbreak of fungal disease in 1967. This outbreak reduced stocks on the River Wharfe and some tributaries to very small numbers and upstream of Addingham they have never recovered. The existing populations are healthy and spawning does take place but the stocks are very low. Following the outbreak no attempts were made to re-introduce grayling of breeding age into the Upper Wharfe as was done on the mid-Wharfe.

Yorkshire Grayling Rivers

Main River	*Tributary*
Tees	
Esk	Not common
Ribble	
– Hodder	
Wharfe	Virtually extinct upstream of Buckden
– Skirfare	A sparse population
– Dibb	At confluence with main river
– Washburn	At confluence with main river

Aire		Upstream of Keighley
Derwent		Upper reaches
	– Rye	
	– Seven	
	– Dove	
	– Costa Beck	
	– Pickering Beck	
	– Thornton Beck	
	– Ricall	
Swale		Upper reaches
	– Cod Beck	
	– Whiske	
	– Bedale Beck	
Ure		As far down stream as Ripon
	– Cover	
	– Skell	
	– Laver	
Don		Introduced into upper reaches
Hull	– Driffield canal	
	– Driffield Beck	
Nidd		
	– Gouthwaite Reservoir	

The stocks appear to be most vulnerable and variable in the tributaries, where the effects of an occasional chemical, farm, or sewage pollution can be severe. This is particularly so during low summer levels or during a period of drought.

Conclusion

Axford (1991) stated at a seminar on 'Yorkshire Grayling', "The rarity of the grayling seems to be a natural characteristic, probably related to habitat restrictions and the grayling are naturally succeeded by trout in the upper reaches. The environmental requirements of the grayling which cause this restriction are not known". He went on to enumerate some of the possible factors.

At the same seminar Crisp said, "The general message which we get from the scientific literature is that when the environment of the grayling deteriorates, the juveniles and young die and the adults move away to more favourable living conditions (Jankovic 1964)".

The author has closely observed the fluctuations of the grayling stocks on the Wharfe (and to a lesser extent on some other rivers) since 1968. Since 1984 angling interests and the National Rivers Authority have been collecting data which it is hoped will give a better understanding of the ecological requirements of the grayling and enable steps to be taken which will preserve this truly wild fish as a denizen of Yorkshire rivers.

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BOOK REVIEW

A Field Guide to the Shallow-water Echinoderms of the British Isles by **Bernard E. Pickton.** Pp. 96 + 66 full colour illustrations. Marine Conservation Society. Immel Publishing, London, £15.95 paperback.

The information contained in this Marine Conservation Society account of the sea lilies, starfish, brittle stars, sea urchins and sea cucumbers is remarkable. Species descriptions are accompanied in all cases by colour photographs taken from life, the quality of which reflect the author's international reputation as an underwater photographer. Whilst aimed at those who dive our coastal waters, most of the species can be found between tides in rock pools and the like. A book which all who have an interest in marine life should have on their bookshelf. Taking into consideration the quality of the illustrations, it is not overpriced.

DTR

VEGETATION CHANGES ON ILKLEY MOOR BETWEEN 1964 AND 1984, AND POSSIBLE ENVIRONMENTAL CAUSES

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INTRODUCTION

In recent years there has been concern about the decrease in the quality and quantity of Britain's heaths and moorlands. This concern has prompted attempts to monitor change in moorland vegetation, and programmes of action designed to halt the decline, both nationally and locally (Bunce, 1989; Hudson & Newborn, 1989a).

In northern England the decline has been brought about partly by a reduction in the areal extent of the moors but mainly by changes in their species composition, with *Calluna vulgaris* (L.) Hull (heather) declining and grasses, *Empetrum nigrum* L. (crowberry) and other species increasing. These changes have been attributed to changed management practices, such as less effective burning regimes and increased sheep grazing (Bunce, 1989). However, there are few detailed quantitative studies of long-term vegetation change. This paper draws upon historical records to determine the nature and extent of change in the vegetation of Ilkley Moor over a twenty-year interval.

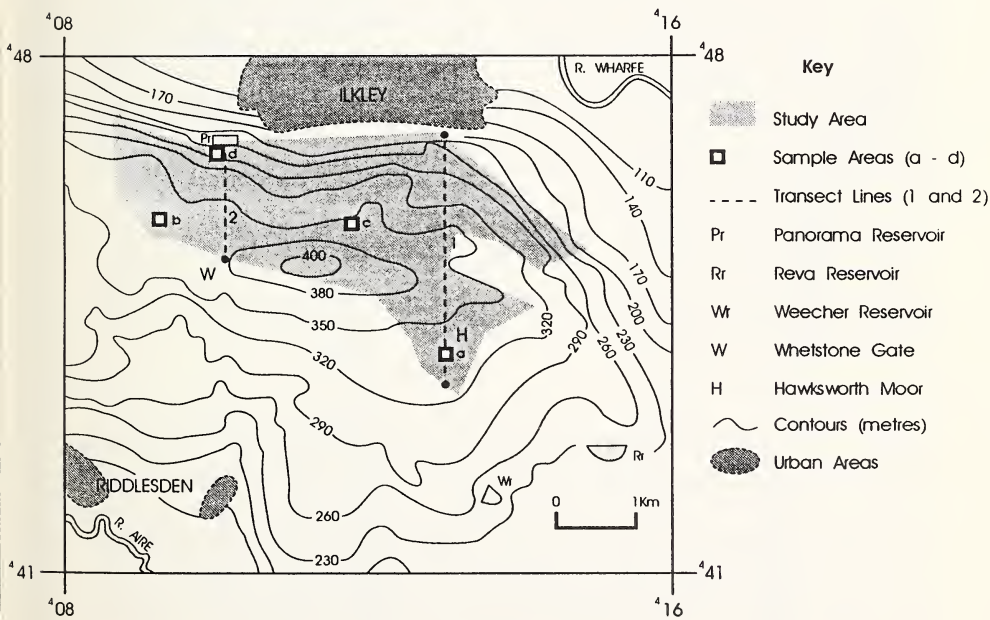

FIGURE 1
Location map showing the positions of the transect lines (1 and 2) and sample areas (a-d) mentioned in the text. The numbers on the edges relate to the National Grid.

In 1974 when Bradford Metropolitan District Council acquired responsibility for the management of the common land on Ilkley Moor, there was general disquiet about the state of the moor. Based on a vegetation survey undertaken in 1964, it was contended that *Pteridium aquilinum* (L.) Kuhn (bracken) and *Empetrum* were rapidly spreading and that *Calluna* was in decline (Fidler *et al.*, 1970). Because of this concern, a new vegetation survey was made of the area in 1984 to provide more recent information about the plant communities on the moor, and to enable comparisons to be made with the earlier survey. This paper analyses the changes which have occurred on the moor in the period 1964-1984 and evaluates possible causes of the observed change such as variation in sheep numbers and climatic trends.

Physical Background

Ilkley Moor and the integral contiguous area of Hawksworth Moor occupy about $10km^2$ of the upland area which separates the rivers Wharfe and Aire (Fig. 1). The underlying geology consists of an alternating sequence of coarse sandstones and shales of Carboniferous age (Lamming, 1969) which dip gently towards the south (Fig. 2). Coarse sandstones cap much of the gently undulating upper portion of the area, which attains a maximum height of 402m close to the moor's southern boundary. Shales are more abundant in the northern, lower portion of the moor where the land slopes steeply into the valley of the river Wharfe. The lowest portion of the moor has an elevation of 160m.

During the Devensian glaciation the area was scoured by ice which moved down the Wharfe valley. The beds of shale were preferentially eroded, steepening the lower, northern slopes of the moor. On the moor's northern flank, landslipping has occurred due to glacial oversteepening. In the mid and upper portions of the moor, glacial erosion produced a number of small sandstone scarps. Sandstone beds also underlie the ill-drained almost horizontal areas which make up large tracts of the moor. Glacial debris, in the form of a calcareous lateral moraine, forms a small but notable feature in the eastern section of the moor (Fig. 2a), but apart from this little glacial debris is in evidence though deep solifluction debris is present on many slopes. Over the sandstone beds the soils are generally thin and stony with a pH of 3.0 to 5.5. Near the crests of the sandstone scarps drainage is good, but waterlogged soils and thin peat deposits occupy much of the flatter dipslope areas. These thin peats are underlain by a mineral soil typically comprising mostly coarse and fine sands (44% and 53% by weight respectively) with a small quantity of silt and clay materials (1% and 2% respectively).

Though meteorological data are not available for the moor itself, data drawn from stations within 9 km indicate that the area has a seasonally well-distributed annual precipitation of 800 to 900 mm. Mean winter temperatures on the moor average about 2°C and mean summer temperatures 13°C. Only during the three summer months will frosts usually be completely absent.

Vegetation Records

In 1903 William Smith published a map of Ilkley Moor as part of his 1:126,720 scale vegetation map of Yorkshire (Smith & Moss, 1903). On this map the upper moor is depicted as 'heather moor (*Calluna* dominant)', with the scarps supporting *Vaccinium myrtillus* L. (bilberry); *Empetrum* is also mentioned as being present. By 1960, however, *Calluna* cover had apparently declined and vegetation changes were attracting the attention of the local naturalists. A map of the vegetation produced in 1964 by the Wharfedale Naturalists, and papers published at that time, highlight the spread of *Empetrum* on the upper moor and *Pteridium* in the lower areas (Dalby, 1961; Dalby *et al.*, 1970; Fidler *et al.*, 1970). They suggested that these changes arose either from excessive grazing by sheep or from the moor drying out following the excavation of shallow ditches which were intended to improve the drainage.

Since the 1960s the vegetation of the moor has continued to change (Cotton & Hale, 1989). This paper quantifies some of the changes and discusses possible causes for the

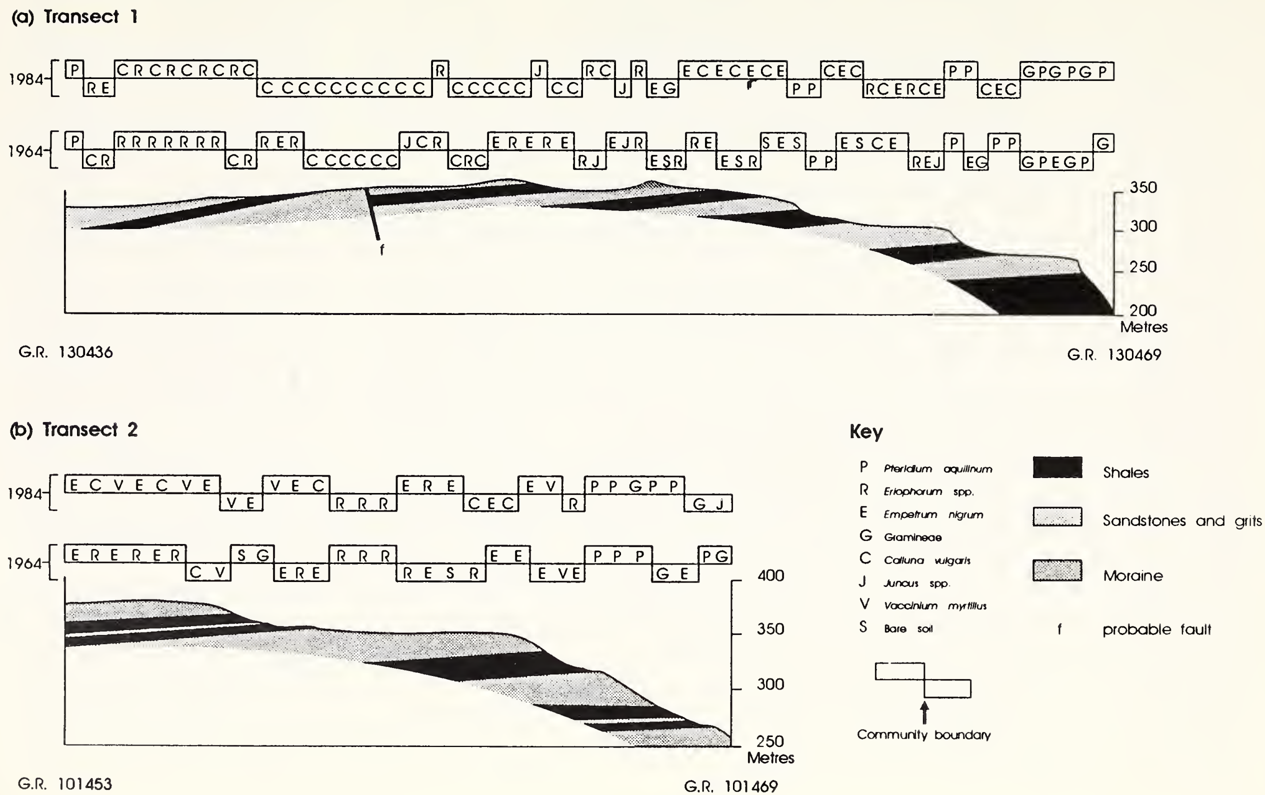

FIGURE 2

Composite cross sectional transects of Ilkley Moor showing topography, generalised geology and vegetation communities as mapped in 1964 and 1984. The letters within each community type give an approximate indication of the relative abundance of the species present. The locations of the transects are given in the text and in Figure 1.

changes between 1964 and the period 1983-1984, when the moor's vegetation was resurveyed.

Data Collection and Methods of Analysis

The 1984 map was produced at a scale of 1:500 to match the 1964 map, a copy of which had been obtained from the Wharfedale Naturalists. Details of the recording procedure in 1984 are given in Cotton and Hale (1989), but in summary involved the following. Ten community categories were used. Six of them were based on the relative proportions of the Ericales species (*Calluna*, *Empetrum* and *Vaccinium*) where these occupied between them over 50% of the vegetation cover. The four remaining categories related to dominance by *Pteridium*, *Eriophorum* species (*E. angustifolium* Honck. and *E. vaginatum* L.) and grass and *Juncus* species (particularly *J. effusus* L.). Percentage cover of a species was not recorded directly, but since the categories were decided using relative abundance of species the approximate cover value of the key species in each category was known. With the 1964 map categories, based largely on dominance of key species, assumptions had to be made about the percentage cover values for each category. For example, in categories where two species were named, it was assumed that the first-named was dominant with a cover of 60% and the second-named was subsidiary with 40% cover.

Quantitative data were extracted from both the 1964 and 1984 maps by superimposing a regular rectangular grid with a line spacing of 33.3m, providing almost 9,000 sample points per map. This gave a sample density of nine points per hectare. At each sample point the vegetation community recorded on the map was noted. The frequency of these community records then enabled estimates of the percentage cover of the moor by different plant species to be calculated for both surveys, as indicated above.

Due to some uncertainty about the most appropriate percentage cover values to apply to the 1964 map categories, it was decided to check the sensitivity of the results under different assumptions. Consequently, the vegetation categories on the 1964 map were assigned to the closest matching category from the 1984 survey, and the percentage cover value for each species in 1964 was then calculated in accordance with the procedures used for the 1984 results. If the results are robust with respect to the different assumptions used, this would give greater confidence in the accuracy of the results estimated. The results presented are therefore of two types: (1) the percentage of the moor occupied by the major species from the 1964 and 1984 surveys as originally classified, and (2) data obtained from the 1964 survey as reclassified.

Composite transects showing the relationship between geology, topography and vegetation in 1964 and 1984 were constructed using the 1934 1:10,560 scale geological maps and the original 1:500 scale vegetation maps (Fig. 2). Both are North-South profiles, located as shown in Fig. l; one is of the eastern section of the moor and runs from near the Cow and Calf rocks (44/130469) to Hawksworth Moor; the other traverses the western portion of the moor from Panorama Reservoir in the north (44/101469) to Whetstone Gate on the moor's southern boundary.

Spatial change in small areas of vegetation was also evaluated for four markedly different moorland environments. The locations of four illustrative areas are depicted in Figure 1. They comprise portions of the upper moorland plateau; the upper sandstone scarp; the poorly-drained plateau of the middle moor; and the steep slopes of the lower moor. Maps have been drawn for both 1964 and 1984 for each of these 25x25m tracts of vegetation (Fig. 3a-d respectively), so that the frequency of the species symbols creates a visual impression of the relative abundance of the species in each of the mapped communities. Comparison between the 1964 and 1984 maps therefore gives a direct impression of estimated species changes.

Data were also obtained on the climatic conditions which have prevailed over the period 1964-1984 in order to determine if there were any trends which may have influenced vegetation change. Precipitation data were obtained for Reva and Weecher Reservoirs, which lie less than 2.5 km from the moor's southern edge (Fig. 1). Further information on

precipitation, bright sunshine and temperatures were obtained for Lister Park in Bradford, which is less than 9 km from the moor. Data from these three sources have been combined to provide a more complete picture of conditions on the moor than would be given by information from any one recording station.

Records of sheep numbers between 1950 and 1988 were obtained from the Ministry of Agriculture, Fisheries and Food (MAFF) annual June returns. These provide details of livestock numbers on agricultural holdings within all the parishes which together constitute the moor. Records of sheep numbers actually on Ilkley Moor came from direct counts made between 1974 and 1978, and were obtained from Bradford Metropolitan District Council.

Results

Table 1 provides data for the estimated percentage areas of the moor occupied by major plant species. The reclassified 1964 data show very little difference (<3%) in the indicated species abundances from the data obtained with the original categories – compare columns (b) and (c). This contrasts with the marked differences between the 1964 and 1984 data – compare columns (b) and (a). This gives confidence that the differences are not merely an artefact of using different mapping procedures in the two surveys.

It is apparent that the estimated cover value for *Calluna* has increased appreciably (from 8.2% to 25.9%) whilst those for *Vaccinium* and *Pteridium* have also increased but by a smaller absolute amount (from 2.5% to 8.4% and 17.3% to 22.5% respectively). However, in percentage terms *Vaccinium* has increased even more than *Calluna* (Table 1). *Empetrum* and *Eriophorum* species have decreased considerably (by an estimated 13.4% and 10.8% respectively). Whilst there is an indication that Gramineae and *Juncus* species have each decreased slightly, the decrease is close to the 3% variation associated with the community reclassification and therefore should be interpreted with caution.

Notable tracts (30ha in total) of the whole moor were recorded as bare ground or burnt areas in 1964, probably reflecting a more active burning regime at that time. By 1984 these had been colonised by vegetation, and no bare ground or burnt areas were recorded. For these colonised areas, *Empetrum* accounted for an estimated 33% of the new cover, *Calluna* for 28% and *Vaccinium* for 16%; the remaining species each had 10% cover or less.

TABLE 1

Percentage of vegetation cover (excluding bare ground) accounted for by species and higher taxa in (a) 1984, (c) 1964 and (b) 1964 as reclassified. Percentage change calculated by ((a)-(b)/(b))x100.

Species	1984 categories (a)	1964 re-classified (b)	1964 categories (c)	% change
Calluna vulgaris	25.9	8.2	7.2	+216
Pteridium aquilinum	22.5	17.3	16.3	+30
Empetrum nigrum	19.0	32.4	35.2	-41
Eriophorum spp.	13.5	24.3	24.3	-45
Vaccinium myrtillus	8.4	2.5	2.1	+238
Gramineae	6.6	10.1	7.3	-35
Juncaceae	4.1	5.2	7.8	-21

Figures 2a and 2b illustrate the relationships between topography, the underlying geology and the vegetation communities. *Pteridium* is associated with the moor's lower scarps and *Calluna* is prevalent on the level tracts of the eastern portion of the upper moor. Over the twenty year period, *Calluna* has increased markedly on Hawksworth Moor and on the central plateau. In contrast, *Eriophorum* species are now abundant only on the western

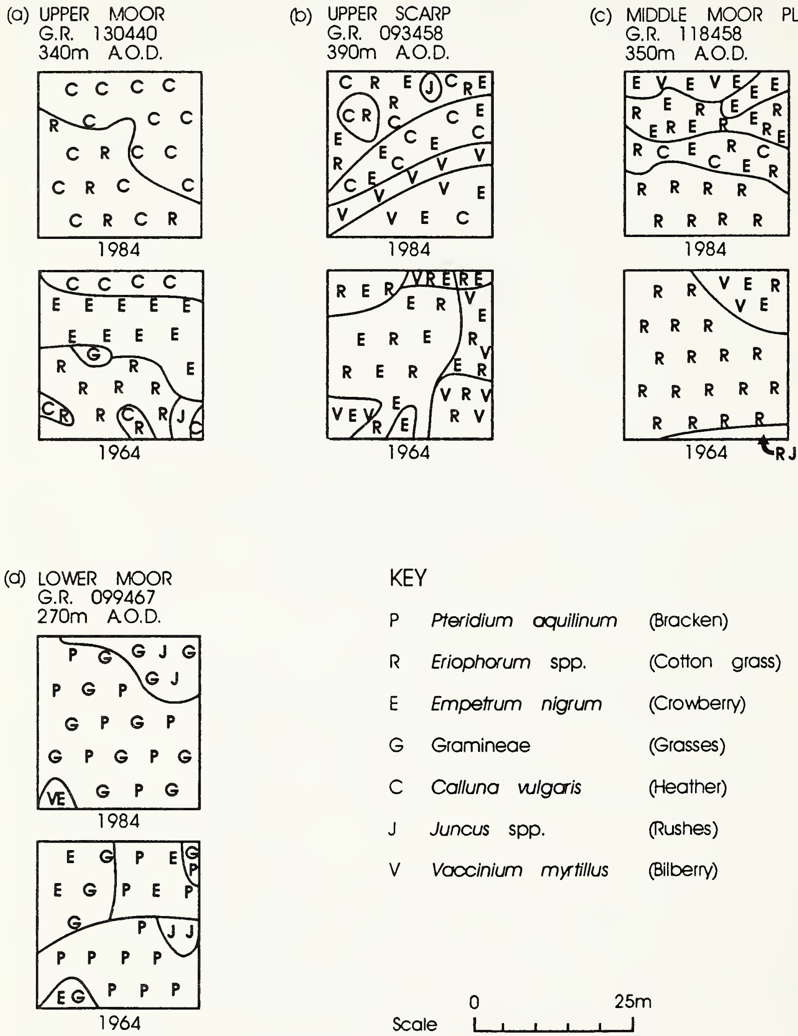

FIGURE 3
Vegetation maps of selected 625m² portions of Ilkley Moor in 1964 and 1984. The lines demarcate the mapped vegetation communities and the letters schematically depict the most abundant species in each community

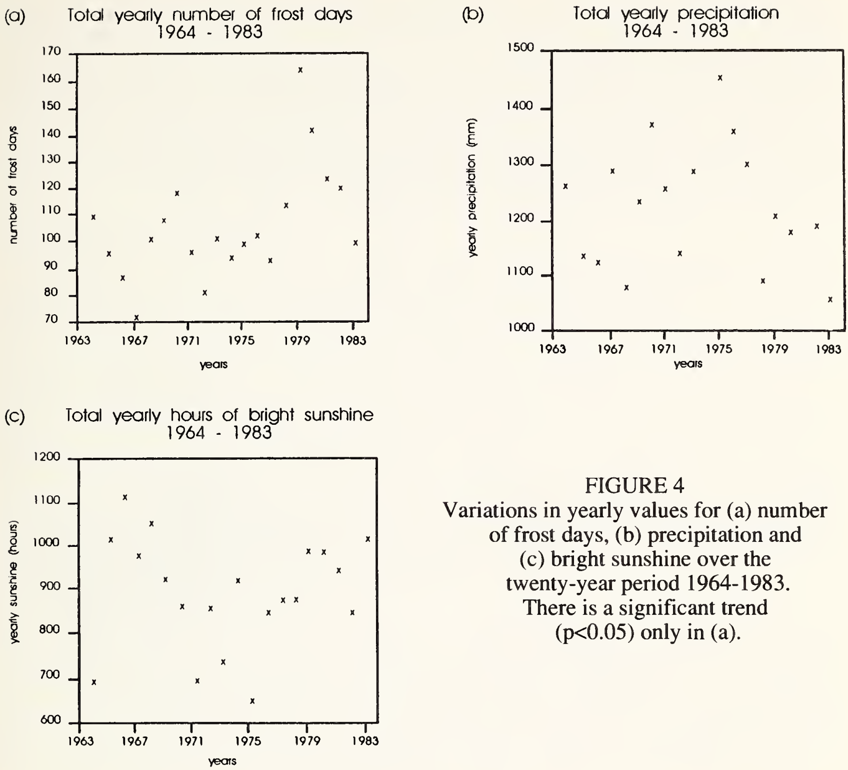

FIGURE 4
Variations in yearly values for (a) number of frost days, (b) precipitation and (c) bright sunshine over the twenty-year period 1964-1983. There is a significant trend ($p<0.05$) only in (a).

section of the central plateau, and have diminished particularly in the upper portion of the eastern moor. *Empetrum* has also declined on the upper moor, but the relationship with relief is less clear. *Vaccinium* has increased on the upper areas of the moor, particularly in the west. *Pteridium* has not extended beyond the lower portions of the moor, but in some areas it has been ousted by *Calluna* and *Empetrum* whilst elsewhere it has expanded at the expense of the *Empetrum*-grass community. Maps showing changes in the spatial distribution of the species on the moor are given in Cotton and Hale (1989).

Comparison of the vegetation maps of different portions of the moor in 1964 and 1984 reveals many changes. On the upper moor (Fig. 3a), *Calluna* has become much more abundant, having spread into large areas that were formerly dominated by *Empetrum* and *Eriophorum*. *Empetrum* now only occurs rarely in the area. On the upper sandstone scarp changes are equally pronounced (Fig. 3b). *Vaccinium* has spread along the crest of the scarp and in 1984 formed a distinct zone. *Calluna* too has become more abundant, with both species occupying areas where *Eriophorum* and *Empetrum* were formerly abundant. On the poorly drained plateau of the middle moor (Fig. 3c), ericaceous species have spread into areas formerly occupied by *Eriophorum*. *Juncus* species have decreased in the area. The biggest change on the lower moor (Fig. 3d) is the general increase in the abundance of *Pteridium*. However, locally Gramineae and Juncaceae have become more abundant and *Empetrum* has declined in the lowest portions of the area.

Analysis of the climatic data for the twenty year period revealed marked fluctuations in most of the climatic elements, but statistically significant trends were confined to the incidence of ground frost. Though there were no significant trends in overall yearly temperatures, the incidence of both spring and autumn frosts increased significantly ($p<0.05$) and the annual incidence of frosts also showed a significant increase ($p<0.05$; Fig. 4a). Though the summer of 1976 was the driest since records began in 1908, the overall annual precipitation showed no significant trend (Fig. 4b). Sunshine data (Fig. 4c) revealed no apparent trend in annual totals over the period, even though the implementation of the Clean Air Acts might have been expected to influence this parameter.

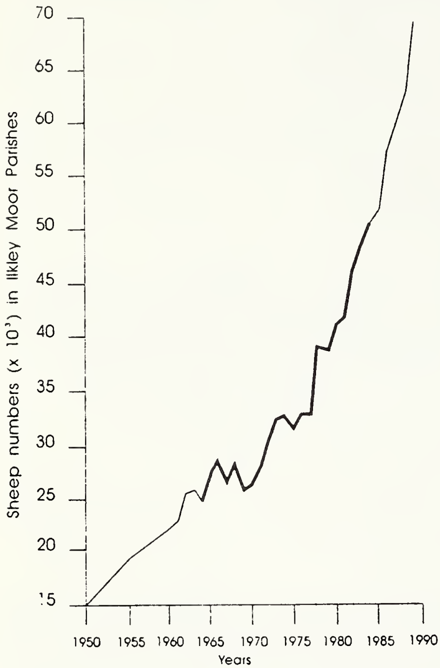

FIGURE 5
Total numbers of sheep recorded by MAFF June returns for all the parishes which include portions of Ilkley Moor. The heavy line depicts the principal study period.

The records of sheep numbers in the moorland parishes indicate that sheep numbers in the area have increased dramatically since 1950 (Fig. 5). In the 20 year period (1964-84) numbers rose from 26,102 to 48,758. Counts of sheep actually on the moor between 1974 and 1978 revealed that numbers varied from approximately 1200 to 1700, suggesting that about 5% of the total sheep population of the parishes was present on the 1000 hectares of moorland.

Discussion

Stocking Density and Effects on Vegetation

The stocking density revealed by sheep counts on Ilkley Moor during the 1970s indicates that at that time there were between 1.2 and 1.7 sheep per hectare. If the numbers of sheep actually on the moor is a constant proportion of sheep numbers in the moorland parishes, then grazing pressure doubled, from about 1 to around 2 sheep per hectare, over the period 1955 to 1980. Similar shifts in stocking density have been associated with changes in the nature of moorland vegetation cover at many sites in Britain (Rawes, 1983; Hobbs &

Gimingham, 1987). Hudson and Newborn (1989a) maintain that, as a rough guide, a grazing density of 1 sheep per hectare is the maximum that will normally allow *Calluna* to maintain itself in the vegetation; while the Nature Conservancy Council have given predictions for heather moorland condition at different stocking densities (Cranbrook, 1991). They predict that heather moorland should be in 'good' condition (i.e. >50% heather cover) when stocked, on average, at <2 ewes per hectare; in 'poor' condition (25-50% cover) at 2-3 ewes per hectare; 'suppressed' (<25% cover) at 3-4 ewes per hectare; and absent at >4 ewes per hectare. They suggest that heather moorland would be likely to disappear in the longer term if stocking rates persist at >2 ewes per hectare . Ilkley Moor therefore had, by 1984, reached a stocking rate at which some deleterious vegetation changes might be expected to occur.

Our results indicate that pronounced vegetation changes have occurred on Ilkley Moor in the period 1964 to 1984. However, the nature of these changes differs from the response to similar increases in grazing intensity recorded elsewhere. When sheep are present at densities of over 1 per hectare, *Calluna* decline has been associated with the spread of *Nardus stricta* L. and other less palatable species such as *Empetrum* (Welch, 1984). In contrast, on Ilkley Moor our data indicate that *Calluna*, *Pteridium* and *Vaccinium* have increased while *Empetrum* and *Eriophorum* species have declined. Examination of the changes in the plant communities on Ilkley Moor (Fig. 3a-d) reveals that different moorland habitats have changed in different ways. Hence, it is probably unwise to regard Ilkley Moor as one single unit when making comparisons with other findings. Clearly, erroneous conclusions could be reached by assuming that observations on change on one moor are directly applicable to the whole of another moor where the habitats may differ. Possible explanations for the observed changes in individual species abundance and distribution on Ilkley Moor are given separately below.

Empetrum Decline

The decrease in *Empetrum* on most of the moor might have arisen from climatic change. On Ilkley Moor *Empetrum* is close to its south-eastern limit of distribution within Britain (Bell & Tallis, 1973). Consequently, any tendency toward warming or drying might be expected to affect it adversely on this site, particularly on the lower slopes of the moor where a marked decrease was noted (Fig. 3d). The annual climatic data, however, show no systematic tendency for change in bright sunshine, temperature or precipitation. There was a slight increase in the number of frost days, but it is unlikely that this would have caused a decline in a species with a northerly distribution. The increase in stocking rates probably would not have led to greater grazing pressure as *Empetrum* is relatively unpalatable. However, increased sheep numbers could have led to an increase in trampling to which this species, with its prostrate stems, would be particularly susceptible (Dalby, 1961; Rawes, 1983).

Pteridium Consolidation

The distribution of *Pteridium* on Ilkley Moor is thought to be limited by altitude and exposure (Fidler *et al.*, 1970). Over the 20 year period the upper limit of the major areas of *Pteridium* has remained below the 350 metre contour, though it has consolidated its hold within the areas it occupied previously. This increased occupancy may be because increased sheep grazing pressure does not greatly affect *Pteridium* due to its unpalatability, and its spread has been widely recorded in other upland areas of Britain (Anderson & Yalden, 1981; Hudson & Newborn, 1989b).

Eriophorum Decline

It is known that sheep have distinct grazing preferences for different species at different times of the year (Hunter, 1962). Therefore, replacement of the *Eriophorum* species by *Calluna* in parts of the moor may well be associated with preferential seasonal (summer) grazing. However, details of such preferences are not entirely understood (Grant *et al.*,

1976), and also it is not known how grazing pressure varied seasonally on Ilkley Moor during the period. Anderson and Yalden (1981) reported that under a regime of increased sheep grazing *Calluna* expanded into areas of *Eriophorum*. They suggest that this spread of *Calluna* might be due to gully-erosion caused by excessive stocking or the digging of drainage ditches. Fidler *et al.* (1970) have also suggested that Ilkley Moor might have been drying out, and that this would adversely affect the *Eriophorum* species. However, these explanations do not seem appropriate to the changes reported here. Drainage ditches only affect the vegetation immediately adjacent to the ditch and are of questionable value in changing plant communities (Stewart & Lance, 1983; Coulson *et al.*, 1990), and indeed on Ilkley Moor such attempts at drainage have long been abandoned. Moreover, there is virtually no evidence of active gully erosion on the middle and upper moor where *Eriophorum* has experienced major decline (Figs. 3a-c). Nor was there any trend to reduced precipitation over this period which might have led to the moor drying out.

A more likely possibility is that the frequency of burning on the moor has declined. Though there are no comprehensive records of past burning, the 1964 map records that large areas of the upper moor had been burned at that time. In contrast, no such extensive areas were recorded on the 1984 map, and field observations from the 1970s suggest that burning did not feature strongly in the management regime in the period between the two surveys. As *Eriophorum* species are known to be early colonisers of newly burned areas and to decline when *Calluna* fully establishes itself (Hobbs & Gimingham, 1980; Hobbs, 1984), the reduced burning may well have reduced the opportunities for *Eriophorum* colonisation and consequently effected a reduction in its abundance.

Calluna Increase – A Delayed Effect?

Calluna has increased over much of the moor, but particularly on the higher areas (Fig. 2). On the upper moor it has expanded into areas that were formerly bare ground and has displaced both *Empetrum* and *Eriophorum* (Figs. 3a,b). Though it has been reported that *Calluna* may be stimulated when low grazing pressures are slightly increased (Welch, 1984), this is probably not an explanation for the major expansion of *Calluna* in this period, particularly as the stocking rates are such that *Calluna* decline might be expected. It is possible that other competitor species may have been worse affected by stocking density, for example *Eriophorum* by summer grazing and *Empetrum* by trampling. Alternatively, the observed increase in *Calluna* may reflect the long-term effects of the extensive burning which was recorded on the 1964 map. Burning is an effective treatment which stimulates the growth of almost pure stands of *Calluna* (Gimingham, 1972). Moreover, the widespread extent of the burned areas would have reduced localised grazing pressures on the young *Calluna* and this, coupled with the relatively low number of sheep in the area in the 1960s, would have facilitated the establishment of *Calluna* at that time. Twenty years later, these *Calluna* stands would have reached the most vigorous and dominant phase of their life cycle, and other species would consequently have been adversely affected.

Conclusions

The records of vegetation on Ilkley Moor present a rare opportunity to observe vegetation changes throughout the twentieth century, and the existence of two detailed vegetation maps allows the quantification of such changes to be made over a twenty year time interval.

Between 1903 and 1964 *Calluna* declined in abundance, but increased substantially from the mid-1960s to 1984 despite an increase in sheep numbers. Though several suggestions may be advanced to explain the observed vegetation change, we consider it most likely that the recent changes are related to the extensive burning which occurred twenty years ago. Climatic parameters over the period 1964-1984 show little consistent variation and are not likely to be the major instigators of vegetation change; neither are the ineffective attempts to drain the moor by digging ditches. The spread of *Pteridium* may be associated with rising sheep numbers in this period, but without further information on seasonal numbers their probable effect on *Calluna*, *Empetrum* and *Eriophorum* cannot be determined.

Notable differences in the fate of species within different communities have been observed in different sections of the moor. Consequently, regarding a moor as one uniform whole may be inappropriate.

Variations in the burning management regimes may account for many of the vegetation changes on the moorland, its current vegetation communities probably reflecting the extensive disturbance that was recorded in the 1960s. Current management practice in operation since 1984, which includes the reduction of grazing pressure, may not maintain the presently improved moorland quality. Indeed, it is possible that the relative abandonment of *Calluna* burning since the 1960s may lead to a deterioration of the vegetation in the coming decades despite the reduced grazing unless there is further active management.

SUMMARY

Records of the vegetation of Ilkley Moor date back to 1903. Detailed maps of the vegetation of 1,000ha of the moor, completed in 1964 and 1984, were compared using a grid of almost 9000 points to determine the vegetation change, notably of the species *Calluna vulgaris* (L.) Hull, *Empetrum nigrum* L., *Pteridium aquilinum* (L.) Kuhn, *Vaccinium myrtillus* L., *Eriophorum angustifolium* Honck. and *Eriophorum vaginatum* L. Although different community classifications were adopted in the two surveys, data derived from the two maps could be compared directly without undue distortion of results. Comparison of the two surveys indicated marked increases in percentage occupancy of *C. vulgaris*, *V. myrtillus* and *P. aquilinum*, and decreases of *E. nigrum* and *Eriophorum* species. The specific changes also varied on different parts of the moor.

Trends in various environmental parameters over the period 1964 to 1984 were assessed to try to explain these changes. There is no evidence to show that drainage operations have been an important factor, nor that there have been any consistent climatic trends that might have affected the vegetation composition. The vegetation changes cannot be explained solely in terms of alterations in grazing pressure by sheep, although the local sheep numbers were found to have increased substantially over this period. Possible effects from trampling by sheep, seasonal grazing, species unpalatability and past burning regime are discussed.

ACKNOWLEDGMENTS

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BOOK REVIEWS

The Freshwater Crustacea of Yorkshire: A Faunistic and Ecological Survey by **Geoffrey Fryer**. Pp. 312, with 58 figures. Yorkshire Naturalists' Union and The Leeds Philosophical and Literary Society, 1993. £16.00 paperback.

This remarkable book is, in my opinion, essential reading for all freshwater ecologists. It is a detailed account of the distribution of Yorkshire's freshwater crustaceans based primarily on the author's own meticulous observations made over several decades. This work is unique in its scope – in the number of sites examined, the number of samples taken, the precision and number of measurements made of environmental parameters, and in the wealth of background information provided on the geology, fauna and flora of the region. The core of the book is the analysis of distribution patterns, both by habitat type and by species, but it also includes short chapters on classification and taxonomy, biogeographical factors and conservation issues. The text is well organised and amply supplied with distribution maps and line drawings of the species.

The regional nature of the work does not, however, mean that the results are only of

regional, or even national interest. In fact, this work clearly demonstrates the paramount importance of making observations at a scale appropriate to the organisms concerned, and raises numerous points of general biological significance:

1. The concept of ubiquity in the distribution of particular organisms has previously been considered on anthropomorphic scales; on the microhabitat scale appropriate to small crustaceans the concept requires much qualification.
2. Acidity is a great restricter of diversity and can exclude a sensitive species from one water body only metres away from another where it breeds successfully.
3. The dispersal ability of freshwater microcrustaceans is emphasised by the temporal dimension of the data.
4. The extraordinary persistence of individual species at given microhabitats, such as a seepage by the side of the road, is demonstrated over extended periods of time.
5. It points to the relative importance of factors such as altitude, soil type and water chemistry in determining distributions of small aquatic organisms.
6. There is a link between small scale distribution patterns and the behaviour of species.

This work is not, to use the modern jargon, big science but it shows that a big contribution to scientific progress can still be made by genuine natural historians. It reminds us that, however much we are able to explain the distributions of living organisms and relate them to environmental parameters, they are not entirely predictable and there will always remain a few occurrences that are inexplicable. I found this book fascinating and I recommend it, as an invaluable reference work, to those working on the ecology of freshwater organisms and to all natural historians interested in the diversity of life. The price is very reasonable and the attractive cover and layout of the text make it suitable as a present.

GAB

Biogeography and Ecology of the Rain Forests of Eastern Africa, edited by **Jon C. Lovett** and **Samuel K. Wasser**. Pp. x + 341 with numerous line drawings & tables. 1993. Cambridge University Press. £75.00 hardback.

Tropical rain forests are disappearing at an alarming rate, and no more so than in eastern Africa. As pointed out by Rodgers in the final chapter of this book, there is a dearth of information on forest conservation; although it is increasingly understood by administrators and planners that forests are essential for our survival, resulting in some cases, e.g. Tanzania, in policies and action plans for long-term sustainable use and conservation of forest resources, this realization has coincided with a period of extreme economic difficulty. There are no local funds to implement enlightened policies, so forest conservation must therefore depend largely on foreign aid.

It is hoped that Rodger's thought-provoking chapter will impress on politicians and donor organizations the necessity of such assistance, but the chapters preceding it are quite clearly aimed as a scientific audience. Short introductory chapters on the geological evolution, climatic history and general biogeography and ecology of east African rain forests are followed by two chapters detailing the flora. The remaining chapters (with the exception of that on conservation) are concerned with forest millipedes, Linyphiid spiders, mountain butterflies, herpetofauna, avifauna and mammals (mainly monkeys). Each chapter reveals the exceptional biodiversity and the high level of endemism within East African rain forests, and together they provide a unique insight into tropical evolutionary processes and the need for effective management practices if they are to be successfully conserved.

It is ironic that the very high price of this important volume will preclude its purchase by those at the sharp end of the problem, namely East Africans, and by students; one can only hope that it will find its way into many libraries so that its research data, and the underlying conservation messages therein, can reach the widest possible audience.

MRDS

Red Data Books of Britain and Ireland: Stoneworts by **N. F. Stewart** and **J. M. Church**. Pp. 143, including numerous line drawings & 8 pages of colour plates. 1992. Available from: Publications Branch, Joint Nature Conservation Committee, Monkstone House, City Road, Peterborough PE1 1JY. £15.00 (hardback), plus postage & packing.

As well as providing an important conservation database for a group of plants severely threatened by the continual disappearance or modification of suitable water systems, this book is also a useful reference guide and should stimulate greater interest in these fascinating plants. Despite the regrettable lack of detailed knowledge of the distribution of many species, the authors have assembled distributional maps and ecological information which present a reasonable picture of the status and vulnerability of 21 out of a total British and Irish charophyte flora of 33 species – obviously a remarkable state affairs when two-thirds of a flora need to be listed in a Red Data Book! The usefulness of this slim volume is extended by the presence of a key to *all* species and a section on the more general habits and habitats of the group. A pity such a high price is levied on publications of such vital importance to understanding and solving conservation problems.

MRDS

Stewart & Corry's Flora of the North-east of Ireland, edited by **Paul Hackney,** with the assistance of **Stan Beesley, John Harron** and **Doreen S. Lambert.** Pp. xi + 419 (including numerous line drawings & b/w plates), plus 8 pages of full colour plates. 1992. Institute of Irish Studies, The Queen's University of Belfast, Belfast BT7 1NN. £17.50, plus £1.00 post & packing.

This completely revised and remodelled edition of S. A. Stewart and T. H. Corry's *Flora* is a worthy successor to the two earlier editions (1888, 1938) and maintains the very high standard of recent local floras which are a hallmark of British and Irish botany.

The *Flora,* which covers the counties of Down, Antrim and Londonderry, includes introductory chapters on the history of the study of the flora (8pp.), some comparisons with the floras of adjoining areas (4pp.), history of the vegetation and influence of man (19pp.), topographical and climatic details (30pp.) and an edited section (8pp.) of Robert Lloyd Praeger's 'Botanist's Guide' from the 1938 edition. The *Flora* is richly illustrated throughout with line drawings (mainly maps) and excellent photographic plates (some in colour), mainly of plants and their habitats.

The major section of the *Flora* (283pp.) is devoted to inventories of vascular plant and charophyte records, the former based mainly on the nomenclature of Clapham, Tutin and Moore (1987), giving detailed data on localities, recorders and dates, as well as succinct, but useful, information on ecology and abundance of each species. Synonymy is provided, but its usefulness in the text is limited by the index (14pp.) which provides full common English names, but Latin names to generic level only. An extensive gazetteer (31pp.) is a particularly helpful feature of the volume.

The editor and his assistants, those who contributed introductory chapters, the many botanists involved in its compilation and the publishers are all to be congratulated on providing a comprehensive source of information which is also very attractively presented.

MRDS

Green Roads in the Mid-Pennines by **A. Raistrick.** Moorland Publishing. Paperback edition 1991. £6.99.

The title and cover of this slim paperback by the late Arthur Raistrick will be inviting to many people who enjoy walking in the Yorkshire Dales. However, the unwary reader may be in for a surprise. Originally published in 1962 as *Green Tracks in the Pennines*, this book has been little altered since the 1978 edition and in many ways falls short of what is expected from a modern guidebook. The introductory chapter is interesting and readable

but extremely brief (five pages). The majority of the following chapters consist of descriptions of the routes taken by the old roads, with insufficient historical and descriptive detail to make the narrative come alive. As the author admitted, many of the tracks are now 'macadamised', which renders the term 'green roads' somewhat euphemistic.

Scant attention is paid to the many changes in the Pennine landscape which have occurred since Raistrick's original fieldwork was carried out. The descriptions of the routes rely entirely on the names of villages, streams, inns, etc, without the benefit of grid references. This makes the text extremely difficult to follow, even with a large-scale map to hand, except for those who already possess an intimate knowledge of the area. The maps in the book are very poor, sketchy affairs, and of little use for illustrating the routes in question. The photographs and drawings, by contrast, are delightful and informative.

In short this book is disappointing in that it provides neither a practical guide for those wishing to walk the green roads nor a detailed historical account of their development for those wishing to learn more about them from the comfort of their armchairs. It may have broken new ground when it was originally published in 1962, but thirty years later the book has a quaint, old-fashioned feel to it. Styles of writing and presentation have changed almost as much as the green roads themselves. The reader of the 1990s is looking for something more modern and 'user-friendly' to guide him or her through the by-ways of old England.

MA

Coppiced Woodlands: their management for wildlife by **R. J. Fuller** and **M. S. Warren.** 2nd edition. Pp. 34 (including 9 figures), plus 4 pages of colour plates. **Woodland Rides and Glades: their management for wildlife** by **M. S. Warren** and **R. J. Fuller**. 2nd edition. Pp. 32 (including 9 figures), plus 4 pages of colour plates. 1993. Joint Nature Conservation Committee, Peterborough. £3.50 (plus postage) each, paperback. Available from: Natural History Book Service Ltd., 2-3 Wills Road, Totnes, Devon TQ9 5XN. (£2 is charged for postage & packing on orders below £10.)

These useful booklets on woodland conservation, first published in 1990 (see *Naturalist* **117**: 62), quickly went out of print due to popular demand. Their return, in revised and expanded form, will be widely welcomed.

The Beast of Exmoor and other mystery predators of Britain by **Di Francis.** Pp. 150, with 4 pages of photographs. Jonathan Cape. 1993. £14.99 hardback, £7.99 paperback.

Initially, I was uncertain whether this book was suitable for review in *The Naturalist*. However, on reading it through I realised it contained a considerable amount of information about large wild cats, such as pumas, tigers and leopards, and their taxonomy, habits and habitat, which any mammalogist would find of interest. Most of the book, which is anecdotal, is about large wild cats roaming the British countryside, causing considerable damage to farming stock, especially sheep. The story starts with the spring of 1983, when farmers on the southern fringes of Exmoor began losing their sheep and lambs at an alarming rate. Local farmers, police and a detachment of marines failed to track down the mystery predator. According to the authoress, Di Francis, who is described as a naturalist, water colour artist and journalist, various expert zoological opinions have been sought and expressed within the book on the possible predator involved. Unfortunately, no satisfactory answer has been found to date, as physical evidence of these elusive predatory cats is very limited. In some ways the book can be described as a naturalist's 'who done it', and would make suitable reading for a long train journey, for, at times, I found it very captivating.

MJAT

Journey into Dolphin Dreamtime by **Horace Dibbs**. Pp. 208 with 22 colour plates. 1993 Jonathan Cape, £8.99.

This is the latest in a long list of successful contributions on dolphins and dolphin therapy by Horace Dibbs. The author introduces the reader to several situations where dolphins not only show a positive empathy to man but also on numerous occasions have a positive therapeutic affect, particularly in areas such as clinical depression. The explanation for this the author locates in the Australian aboriginal ethos and philosophy of spatial identity with the environment, or their dreamtime. The author's arguments are at times difficult to follow although the overall presentation is interesting and stimulating.

MJD

The Golem. What everybody needs to know about science by **Harry Collins** and **Trevor Pinch**. Pp. xii + 264, including line drawings & tables. Cambridge University Press. 1993. £10.95 hardback.

A series of case studies for different scientific disciplines are fascinatingly portrayed by the authors, who show that science is not "the straightforward result of competent theorization, observation and experimentation". Of particular interest to readers are the chapters on 'edible knowledge' (the chemical transfer of memory in planarians), 'the germs of dissent' (spontaneous generation of life) and 'the sex life of the whiptail lizard' (pseudocopulatory behaviour and its possible role in priming reproductive mechanisms). Written in a lively style, but one all too typical of the social scientist, this work will make stimulating reading, with such interpretive gems as ". . . 17000 trained goldfish gave their lives in the production of 750 grams of colour discriminating brains . . ." (p.23) and ". . . the number of 'love bites' the lizards underwent and whether or not they waved their hands as a sign of sexual submission both became important" (p.117).

IJH

Microscopic Life in *Sphagnum* by **Marjorie Hingley**, illustrated by **Peter Hayward** and **Diana Herrett**. Pp. 64, with 4 colour plates and numerous b/w illustrations. Naturalists' Handbook no.20. Richmond Publishing, Slough. 1993. £13.00 hardback, £7.95 paperback.

Many naturalists and academics will find this book an inspiration for further studies into the various forms of life found in and amongst the leaves of *Sphagna* (bogmosses). It briefly covers the type and variety of habitat in which species of *Sphagna* are found and their physical and chemical environment. The comprehensive review of the life forms found in and on their leaves is clear and concise. The excellent illustrations and key can be used to identify some of the life forms at least to genus level. The book includes the following: algae, cyanobacteria, flagellates, naked amobae, helizoans, testate rhizopods, ciliates, rotifers, flatworms, nematodes, segmented worms, gastrotrichs, crustacea and mites. One of the strengths of this small book lies in the many projects or investigations that it could generate, with suggestions on how they can be carried out with little expense other than a good microscope. I would highly recommend this title to both botanists and zoologists.

ADH

The Earth as Transformed by Human Action: Global and Regional Changes in the Biosphere over the Past 300 years edited by **B. L. Turner, W. C. Clarke, R. W. Kater, J. F. Richards, J. T. Mathews** and **W. B. Meyer**. Pp. xvi + 713, including numerous black and white illustrations and photographs. Cambridge University Press. 1993. £27.95 paperback.

The reviewer must admit to not having read all of this book, and most probably never will read every word; however, he does expect to go on referring to it for the rest of his

professional life! *The Earth as Transformed by Human Action* is a monumental book both in size and inclusiveness, with 713 pages of very small print. It contains 42 chapters each written by acknowledged experts plus Foreword, Preface and Postscript.

The work is very much in the vein of the influential and authoritative work *Man's Role in Changing the Face of the Earth* (W. L. Thomas, 1956, Chicago University Press). The work under review arose from a meeting convened by the Geography Department at Clark University in 1987 as part of the universities centennial celebrations. As such the contributions have a strong 'geographical flavour' which makes the important environmental issues covered amenable to the lay reader. After a thoughtful introduction by the principal editors, the volume is divided into four sections: Changes in population and society (7 chapters); Transformations of the global environment, sub-divided into Land, Water, Oceans and atmosphere, Biota, and Chemicals and radiation, (19 chapters); Regional studies of transformations (12 chapters) and Understanding transformations (3 chapters). Among the many stimulating chapters those covering carbon (by R. A. Houghton and David Skole), sulphur (by R. B. and J. D. Husar) and nitrogen and phosphorous (by V. Smil), are notable as models of clarity and conciseness.

This is a blockbuster of a book, excellently produced, with good clear illustrations, and modestly priced. It should be read by all who have an interest in man's effect on the environment, and like *Man's Role in Changing the Face of the Earth* is likely to be a standard source of ideas and examples for many years to come.

DEC

CONTRIBUTORS

INDEX

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